AERONAUTICAL ENGINEERING REVIEW

JUNE 1951

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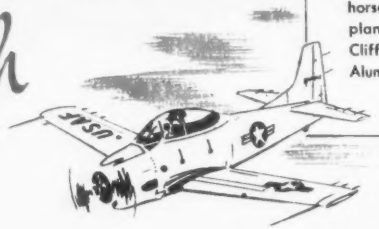

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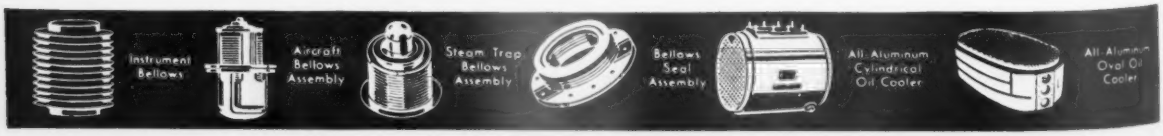

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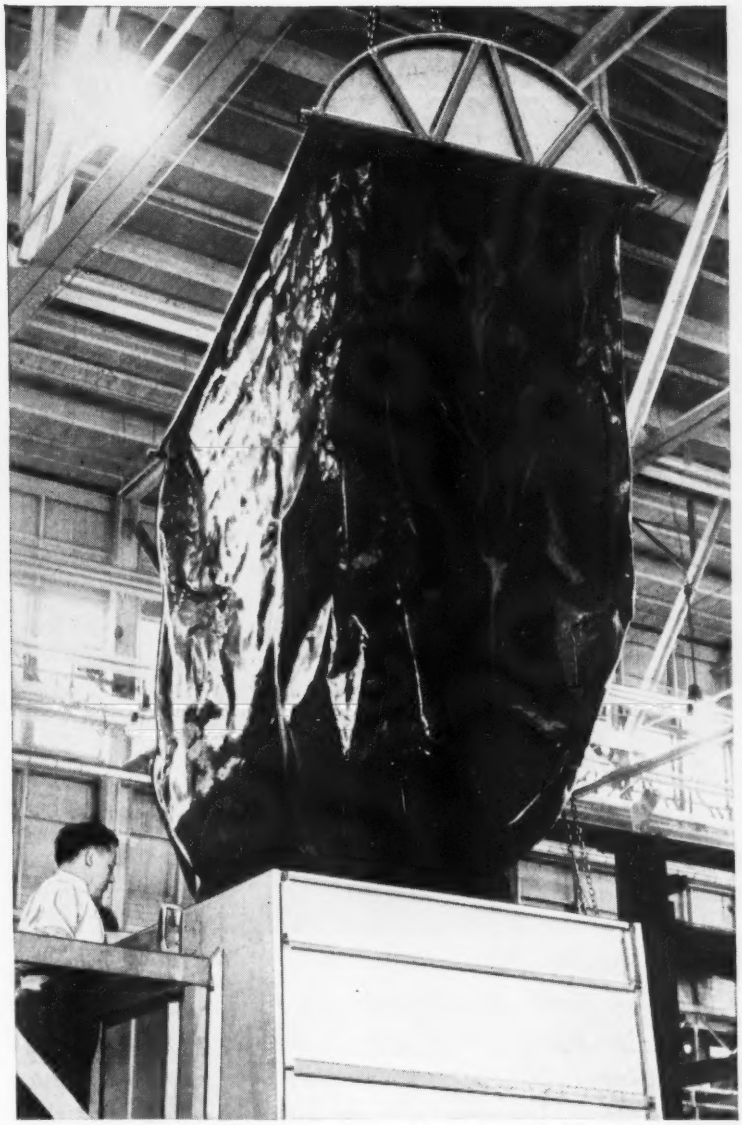

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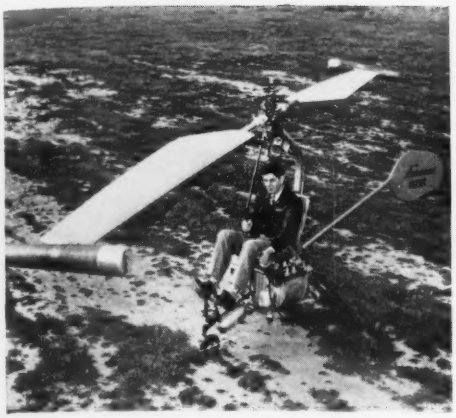

Cover—This single-place Model XA-6 helicopter, manufactured by American Helicopter Company, Inc., can remain in the air without refueling for about 90 min. This helicopter, which has an empty weight of 200 lbs., is powered by two A.H.C. tip-mounted pulse-jet engines.

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AERONAUTICAL ENGINEERING REVIEW

Vol. 10 JUNE, 1951 No. 6

Contents

I.A.S. News 5

Editorial 8

Guest Editorial—Life Begins at Sixty-Five. . . . . .Dr. Nathan A. Bowers 9

Articles

The Air Force Procurement and Expansion Program . . . . . .John A. McCone 12

Closed-Circuit Oil System for Turbojet and Turboprop Aircraft Engines. . . . .P. H. Schweitzer 16

Fatigue Problems in Transport Aircraft . . . . . .William T. Shuler 20

Desirable Longitudinal Flying Qualities for Helicopters and Means to Achieve Them . . . . . .F. B. Gustafson 27

I.A.S. Previews 35

Reviews

Aeronautical Reviews 85

Books 119

Special I.A.S. Publications 131

I.A.S. Preprints. 132

Personnel Opportunities 135

Index to Advertisers. 138, 139

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I. A. S. News

A Record of People and Events of Interest to Institute Members

Commanding General, A.M.C., To Be Principal Speaker at Summer Meeting Dinner

Lieutenant General B. W. Chidlaw Featured at June 28 Dinner; Bane and Chanute Awards To Be Presented Then; June 27–28 Program Tentatively Scheduled.

Lieutenant General Benjamin W. Chidlaw, U.S.A.F.

THE 1951 ANNUAL SUMMER MEETING, which concludes the two-day assemblage of aeronautical personalities, gives promise of being an occasion of great moment. Guest of Honor and principal speaker this year will be Lt. Gen. Benjamin Chidlaw, whose election as an I.A.S. Fellow was announced at last January's Honors Night Dinner. General Chidlaw is presently the Commanding General of the Air Force's Air Materiel Command. The Bane and Chanute Awards will be presented to their respective recipients during the dinner, which will be held in the Embassy Room of Los Angeles' Ambassador Hotel on Thursday, June 28.

▸ **The Speaker**—General Chidlaw, a graduate of the U.S. Military Academy in 1922 and the Air Corps Flying School in 1924, has been directly concerned with Air Force materiel for most of the last 20 years. In this connection, he has served in Aircraft Design as Engineering and Procurement Officer; with G.H.Q. Air Force in Research and Development and as Chief of Materiel Division; and with A.M.C. as Head of Research and Development and as Deputy Commanding General. He assumed full command in 1949.

The general was named by the late Gen. H. H. Arnold to head the development of the first U.S. jet-propelled aircraft. Among other outstanding achievements, he was responsible for transforming the old Air Corps Engineering School, of which he is a graduate, into the present Air Force Institute of Technology.

▸ **Technical Sessions**—Registration, as in the past, will begin promptly at 8:30 a.m. the morning of the first day, June 27. As this issue goes to press, the schedule for the five sessions and their respective papers has been set up tentatively as follows:

Wednesday, June 27

Aerodynamics — Morning Session

The Three-Dimensional Boundary Layer—W. D. Hayes, Brown University.

Experiments on Interaction of Shock Waves and Cylindrical Bodies at Supersonic Speeds—M. V. Morkovin, E. Migotsky, and H. E. Bailey, University of Michigan.

New Theory of Transition from Laminar to Turbulent Flow—Howard Emmons, Harvard University.

A Study of Transonic Gas Dynamics by the Hydraulic Analogy—E. V. Laitone, University of California.

Stability and Control — Afternoon Session

Some Experiences of a Manufacturer with Power Operated Aircraft Control Systems—L. C. Josephs and C. A. Lau, Chance Vought Aircraft Division, United Aircraft Corporation.

Analysis of Systems for Automatic Control of Aircraft—James B. Rea, Consultant, Douglas Aircraft Company, Inc.

Research on the Perturbations of an Airplane's Flight Path Due to Large Scale Air Turbulence, and a Determination of the Power Spectral Density of the Gust Structure—U. O. Lappi and W. N. Turner, Cornell Aeronautical Laboratory, Inc.

An Analytical Approach to the Fuel Sloshing and Buffeting Problems of Aircraft—Harold Luskin and Ellis Lapin, Douglas Aircraft Company, Inc.

(*Continued on page 6*)

National Meetings Calendar

June 27–28, 1951 Annual Summer Meeting, Los Angeles

For Details see page 26

Design *Evening Session*

The Viking Rocket—W. G. Purdy, The Glenn L. Martin Company.

Operational Aspects of Turbojet Transports—R. Dixon Speas, A. V. Roe Canada Limited.

Thursday, June 28

Propulsion Problems in Aircraft Design *Morning Session*

Ejectors for Cooling a Turbojet Installation—H. C. Towle and F. V. H. Judd, Republic Aviation Corporation.

Aerodynamic Forces Associated with Inlets of Turbojet Installations—D. D. Wyatt, Lewis Flight Propulsion Laboratory, N.A.C.A.

Generalized Approach in Selecting Propulsion Systems for Aircraft—L. R. Woodworth and C. C. Kelber, The RAND Corporation.

Structural and Design Problems Afternoon Session

Autopilot Flight Tests on the Constellation—R. L. Thoren and W. L. Howland. Lockheed Aircraft Corporation.

An Investigation of the Effects of a Varying Tip Weight Distribution on the Flutter Characteristics of a Straight Wing—W. H. Gayman, Northrop Aircraft, Inc.

Equilibrium Temperature of an Unheated Icing Surface As a Function of Air Speed—B. L. Messinger, Lockheed Aircraft Corporation.

On the Deflection of Swept Cantilevered Surfaces—H. C. Martin and H. J. Gursahaney, University of Washington.

American Helicopter Joins I.A.S.

The American Helicopter Company, Inc., of Manhattan Beach, Calif., has recently become a Corporate Member of the Institute of the Aeronautical Sciences. A California organization since July 2, 1947, this company has been engaged in research and development work on pulse-jet-propelled helicopters for about 3 years.

The company's first helicopter was the Model XA-5, designed and constructed with private capital. Continuation of the development of this aircraft has been conducted under contract with the Air Force's Air Materiel Command since May, 1949. Further improvement of the pulse-jet engines and rotors has been the company's basic objective. Efforts toward this end have resulted in a jet helicopter that is said to be simple, serviceable, and reliable and to possess a high-performance potential.

The latest thing in pulse-jet helicopters that has been announced by American Helicopter Company is its Model XA-6. This single-place helicopter can remain in the air for approximately $1^1/_2$ hours without refueling and has an empty weight of only 200 lbs. It apparently approaches the ultimate in mechanical simplicity. The service life of the pulse-jet engines used in this aircraft has proved to be well over 50 hours; maintenance required after this period consists merely of the replacement of a small valve assembly. This change can be accomplished with a minimum of labor, time, and cost.

This company, in addition to manufacturing pulse-jet engines and helicopters, is engaged in other developmental and manufacturing activities. These include Air Force trainer-demonstration devices, as well as sheet-metal and milling-machine production of airframe components. A 60-ft. Onsrud Spar Mill is one of the main machine tools operated by the company. It is used for milling airplane spar caps and helicopter rotor blades.

The plant facilities of American Helicopter are being currently expanded to accommodate increased volume in both the Research and Development and the Production divisions. Its most recent acquisition is a large plant facility at Falcon Field near Phoenix, Ariz., for further development and manufacture of the pulse-jet helicopters.

The principal officers and management personnel of American Helicopter are: President and General Manager, Corwin D. Denny; Vice-President—Engineering, Howard E. Roberts; Executive Vice-President, Richard A. Getz; Secretary, John A. White; Treasurer, Joseph F. Schneider; and Research and Development Manufacturing Superintendent, Alan C. Thomson.

TOP MEN AT AMERICAN HELICOPTER: *Corwin D. Denney, President and General Manager, American Helicopter Company, Inc. (left) and Howard E. Robert, Vice-President—Engineering, are shown examining a company-designed pulse-jet engine installed on the tip of a helicopter rotor blade.*

Medaille de l'Aéronautique Awarded Captain Pritchard

Captain J. Laurence Pritchard, H.F.I.A.S., retiring Secretary, The Royal Aeronautical Society, was awarded the Medaille de l'Aéronautique on February 23 by the Association Française des Ingénieurs et Techniciens de l'Aéronautique, the French counterpart of England's R.Ae.S. and America's I.A.S. The award was presented for his "services to French Aviation." This is the first time that this particular distinction has been conferred in England.

After the presentation ceremonies were completed, Captain Pritchard's successor to the post of R.Ae.S. Secretary was announced by G. P. Bulman, R.Ae.S. President. He will be Dr. A. M. Ballantyne, Senior Lecturer, Civil and Municipal Engineering Department, University of London. Dr. Ballantyne is expected to assume his new duties in either June or July.

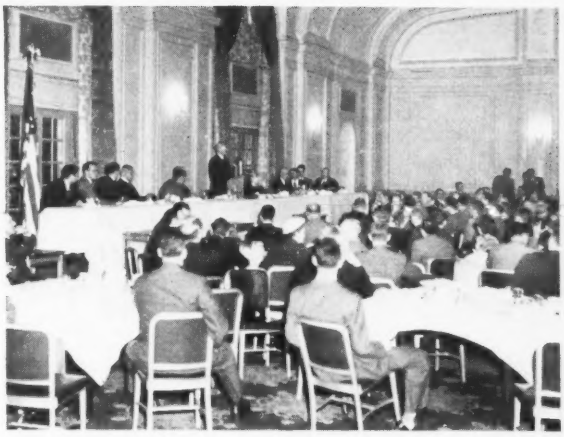
Aeronautical Engineering Catalog Available

The Seventh Annual Edition of the AERONAUTICAL ENGINEERING CATALOG is now available gratis to I.A.S. members by writing to the Director of Publications, Institute of the Aeronautical Sciences. The purchase price to nonmembers is $5.00.

(Continued on page 38)

A Report on the SIXTH NATIONAL FLIGHT PROPULSION MEETING

Cleveland, Ohio, March 16, 1951



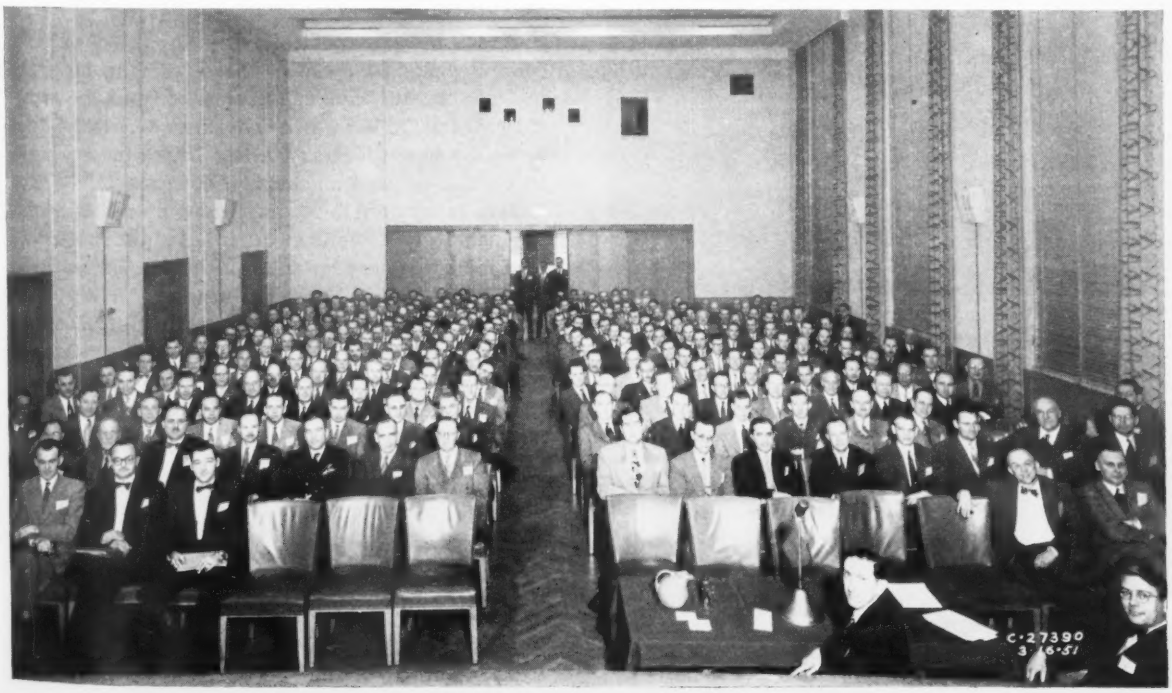
THE SECURITY-CLASSIFIED NATURE of the papers plus the limited seating capacity of the auditorium restricted attendance at the Sixth Annual Flight Propulsion Meeting to slightly under 300 military-cleared persons. Morning and afternoon technical sessions, held in the auditorium of N.A.C.A.'s Langley Memorial Laboratories, provided some interesting papers and discussions on present-day propulsion projects and problems.

Proceedings of the meeting are being compiled and published by the Central Air Documents Office of the Navy and Air Force at Dayton, Ohio. Distribution of the proceedings to authorized delegates attending the meeting and to other cleared and qualified agencies is also being handled by CADO.

▶ **Reception**—Following the technical sessions, a reception, sponsored by nine local manufacturing companies, was held in the ballroom of the Hotel Carter. Here, some 350 people were guests of American Steel & Wire Company, Brush Development Company, Cleveland Pneumatic Tool Company, The B. F. Goodrich Company, Jack & Heintz Precision Industries, Inc., The Parker Appliance Company, Pesco Products Division of Borg-Warner Corporation, Thompson Products, Inc., and Tinnerman Products, Inc.

▶ **Dinner**—Both the reception and the dinner were open to all Institute members and their guests. Although many of the out-of-town delegates to the meeting found it necessary to catch early planes and trains out of Cleveland, over 250 persons remained for the dinner and heard The Honorable John J. McCone, Under Secretary of the Air Force, deliver an enlightening address on "The Air Force Procurement and Expansion Program." The full text of Mr. McCone's talk is published elsewhere in this issue.

I.A.S. President Lawrence B. Richardson, who served as toastmaster at the dinner, expressed the sentiments of the entire group when he introduced, and paid tribute to, the officers of the Cleveland-Akron Section and personnel of N.A.C.A. It was the efforts and cooperation of these people which made this Propulsion Meeting one of the most valuable and successful ever held in Cleveland.



William F. Durand

Editorial

An Appreciation—

Somewhere in the world there *may* exist an aeronautical engineer who has never heard of Dr. William Durand. [In this unlikely circumstance, we can be certain of two things—(a) that he is very, very young and (b) that he has been educated in one of those countries where everything good, including aircraft, was invented by someone named Ivan or Boris.]

Nowhere in the world, however, exists an aeronautical engineer (regardless of age or condition of servitude) whose work has not been influenced by Dr. Durand. There is no facet of aeronautical development which has not been exposed to the impact of his brilliant mind. No single individual that we can think of has contributed so much to so many aeronautical fields.

Most amazing, perhaps, is the fact that the greater part of Dr. Durand's contribution was made when he was over 60 years of age—and mostly *after* his "retirement." At a time of life when most men are putting aside their tools for a well-earned rest, Dr. Durand ploughed steadily ahead, making his influence felt in ever widening circles. This is the aspect of Dr. Durand's life which is discussed by Dr. Nathan Bowers, a long-time associate of Dr. Durand's, in the article that appears on the opposite page.

Here is inspiration for all of us who are no longer young and who sometimes are inclined to coast a bit—even though we are far short of the years attained by Dr. Durand when he began to "retire." A Wise Man once advised all sluggards to consider the busy ant and mend their ways. We should rather keep the example of William Durand before our eyes, take a firmer grip on our pencils, on our slide rules—and especially upon ourselves—and plunge boldly ahead. To slacken the pace is to court disaster. Professionally, we must be good—and continue to be *good*—even "to the last drop."

S. P. J.

"Life Begins at Sixty-Five—"

The 27 Years Since Dr. Durand's Official Retirement Have Been Full and Profitable—An Inspiring Example to Every Engineer.

by

Dr. Nathan A. Bowers
Consulting Engineer

Those who approach retirement age with trepidation may be surprised to find that the 20 years after retirement may well be the most useful period of a man's life. Proof of this, as well as illustration of how it can be brought about, is found in the example set by Dr. W. F. Durand, Stanford's emeritus professor of mechanical engineering, who was 92 last March.

When he retired at the age of 65, 27 years ago, he saw his greatest opportunity in the years yet to come and proceeded to use his previous work as the foundation for a magnificent superstructure—something that no one else could build because the construction material was his own lifelong experience.

Most men would have been satisfied—indeed, proud—to leave as a life record what Dr. Durand had accomplished before retirement. They would have said, "Now I can rest and leave further progress to the next generation." But he had a higher purpose. His alert mind saw that his active life could be used as a basis for further important service to his profession and to his country.

What he did with these "borrowed-time" years led the President of the United States to say, when conferring the highest honor the Government can bestow upon a private citizen, that Dr. Durand "applied the initiative and leadership necessary for the success of American research in several fields of science" and that "by his example and counsel and with characteristic modesty, he guided and inspired research workers to accomplishments which contributed to the success of the United States in war."

Six of Dr. Durand's gold medals, as well as the Wright Brothers Trophy, were won in the post-retirement period. How did this come about? If you would sit down and discuss with him the successive steps in his work, you would find that he has lived by the principle of first acquiring a clear understanding of the fundamentals and then applying that knowledge patiently and intensively in studying obstacles that stand in the way of progress.

At the age of 21, he graduated (with honors) from Annapolis and then served seven years in the Navy. His observation of Naval craft impressed him with the need for improvement in the design of ship propellers. In fact, at that time, "design" of propellers was mostly by guess. To remedy this situation, he carried out a long series of tests in the hydraulic laboratory at Cornell University.

This research, financed by the Carnegie Institution, resulted in establishing the first scientific basis for design of marine propellers. In place of the previous "guess" method, he provided reliable formulas co-relating the three factors he had found to be essential—namely, (1) area of blade, (2) pitch ratio, and (3) distribution of pitch radially along the blade. It should be noted here that these are the same three factors that he studied later in his still more important research in aerodynamics. The mathematics involved are basically the same since both fields are branches of fluid mechanics. However, a long period of teaching was to intervene between the work on marine propellers and application of these same principles in aerodynamics.

In the following, no endeavor is made to review all of Dr. Durand's work and achievements. The purpose is simply to highlight those activities that make his post-retirement life an inspiring example to young and old alike.

His contributions to the aeronautical field began long before his 1924 "retirement." He was one of the "original twelve" members of the National Advisory Committee for Aeronautics (N.A.C.A.) when it was formed in 1915, and, after the entry of the United States into World War I, Dr. Durand was chosen as N.A.C.A. Chairman. In that capacity he planned and directed a program of aerodynamic research which kept the United States a world leader in this field.

When the war ended, he was still interested in further research on aircraft propellers. This he outlined to the N.A.C.A. Board, and they, agreeing fully with his objectives, authorized a program of tests which Dr. Durand supervised in a small wind tunnel built under his direction at Stanford University.

As he had done earlier in the hydraulic field, Dr. Durand now used the laboratory in working out a scientific basis for improved aeronautical design. Over a period of 14 years, the Stanford tunnel tested more than 100 propeller models, working out in terms of aerodynamics many of the same fundamentals and exploring the same three basic factors he had studied so thoroughly in hydrodynamics.

Retirement brought Dr. Durand, among other things, time for one of his most ambitious undertakings. He had long realized the need for collecting and compiling into one encyclopedic work all the theory and basic principles that underlie the broad subject of aerodynamics up to the supersonic field. Such a project, if it could be carried out, would make available, in a form convenient for future designers, the wide range of basic data thus far developed.

This would be an undertaking no one man could carry through alone, but it did call for one man who could be the inspiration and the guiding spirit—a sort of conductor in a symphony of science. This leadership Dr. Durand could and did supply. He somehow managed to coax and encourage the leading scientists in the field of fluid mechanics in the United States, France, England, Germany, Poland, Holland, and Italy to produce in written form summaries of their findings in each of their specialties. These he edited and combined with his own personally developed data into a 20-part, six-volume masterpiece of scientific writing covering the entire field encompassed by the title *Aerodynamic Theory*.

With typical modesty, as Editor-in-Chief, Dr. Durand had excluded himself from the original schedule of contributors to the comprehensive work. However, when some writers failed to produce the promised material, he could and did write the required sections himself. Although mathematical, they are models of lucid style.

This seven-year editing task was completed, and the books were published in 1934 and 1935. Unfortunately, American publishers were afraid to undertake so ambitious a book project in times of depression, and Dr. Durand was obliged to place the manuscript with a German publisher. When World War II brought a rush for texts to serve in training aerodynamic engineers, the supply of books available in this country was quickly exhausted. Thus, a work rated as a "must" in the training of aerodynamic engineers suddenly was no longer available—in effect, it was out of print. The importance of the work is indicated by the fact that, as a Government-approved wartime necessity, all six volumes of it were promptly made available in quantity by photo-offset reproduction!

In the late 1930's, there was a country-wide search for a site on which to locate a great aerodynamic laboratory for Government-sponsored research. After considering many locations, the committee in charge selected the one Dr. Durand favored—namely, Moffett Field, near Palo Alto, Calif. Here construction began in 1940 on Ames Aeronautical Laboratory, which was dedicated for the N.A.C.A. by Dr. Durand in 1942. Here, too, Dr. Durand continued to encourage aerodynamic engineers with friendly interest and wise counsel. The work at Ames has now gone far beyond early objectives, through the sonic barrier and on into the supersonic realm.

An impressive feature of Dr. Durand's method of working is his habit of doing things with a total absence of selfish motives. One of his colleagues recently put it this way: "His modesty, thoughtfulness, and consideration inspire confidence and his notable ability to think and write clearly insures progress in any activity he undertakes."

In time there began to be national and international recognition of the sort of unselfish devotion to science he had rendered in his many research undertakings. In 1935, eleven years after retirement, impressive honors began to gravitate to Dr. Durand. It is only fair to mention here that he did achieve one important medal as a young man. This was in 1899 when the American Society of Naval Engineers offered an award for the best essay on a Naval subject. Dr. Durand submitted a paper on "Electrical Propulsion for Naval Craft" for which the first award of this medal went to him. All of his other gold medals, however, were earned after retirement.

The first of these later recognitions, the Guggenheim Medal for 1935, was awarded by a board of eight members from the United States and one each from Canada, England, France, Germany, Holland, Italy, and Japan. Only an internationally known scientist can qualify for this honor—one of the highest distinctions an engineer can achieve. The citation accompanying this award commended Dr. Durand's "notable achievement as a pioneer in laboratory research and theory of aeronautics and for distinguished contributions to the theory and development of aircraft propellers."

The same year also brought him the John Fritz Medal, which is awarded only after the candidate has been considered for a year by a board consisting of four members from each of the national societies of civil, mechanical, mining, and electrical engineers (the founder societies). Selection of Dr. Durand for this honor was "for achievement in applied science, for distinguished service as authority in hydrodynamic and aerodynamic science and its practical applications; an outstanding leader in research and engineering education."

Three years later (1938) one of the oldest American scientific organizations, the Franklin Institute, founded in 1824 for promotion of mechanical arts, awarded him the Franklin Medal in recognition of "his notable achievement as pioneer in laboratory research and

theory of aerodynamics and of his diversified and distinguished contributions to the science of hydrodynamics and aerodynamics, particularly to the advancement of the theory and development of aircraft propellers."

Dr. Durand seemed always to have ability to get results on special committees, and he somehow found time to serve on many of them. In 1925 he served on the President's Aircraft Board (the so-called "Morrow Board") whose recommendations were so influential, and he was a member of the National Academy of Sciences Committee to consider causes of disasters to the lighter-than-air craft Akron and Macon.

Retirement brought increased activity of this sort. The value of his services was already widely known, and, when release from classroom duties made him available, there was immediate demand for his counsel on major projects. Hoover, Grand Coulee, and Shasta Dams typify the scale of work to which he was called by the U.S. Bureau of Reclamation and other agencies.

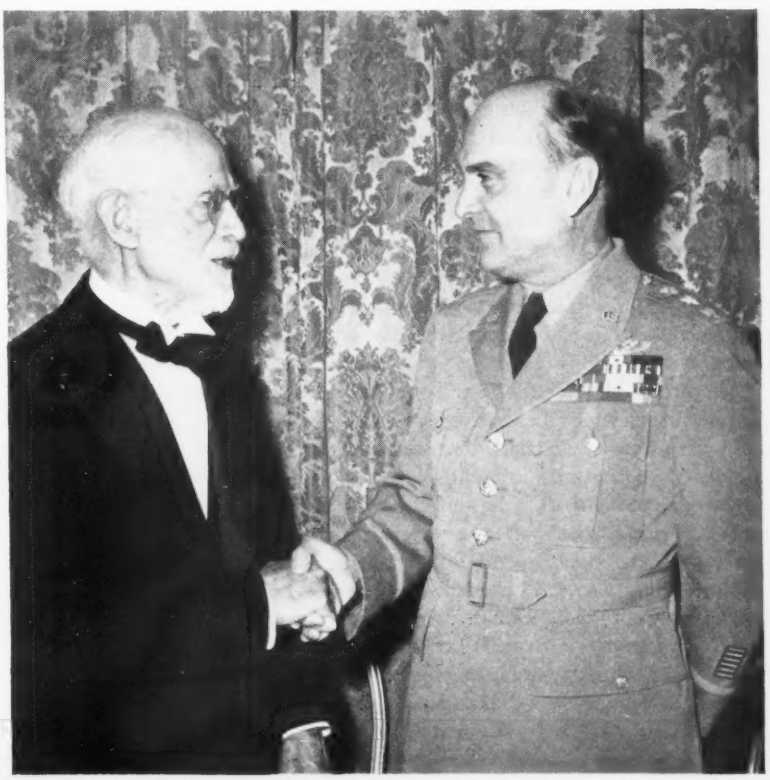
Disregarding age exemption, he was on voluntary duty in Washington in the 1940–1945 period and carried heavy responsibility. For example, he was Chairman of the Engineering Division of the National Research Council and also Chairman of the N.A.C.A. Special Committee on Jet Propulsion. In this latter capacity, he was the key man in originating research and in the initial guidance of industry in development of jet engines. Thus, his active life encompasses an amazing span of scientific contributions ranging from the era of wooden ships to the age of jet propulsion of aircraft.

In 1944, the National Academy of Sciences presented him with the John J. Carty gold medal, awarded for notable leadership in engineering work. In the presentation of this medal, it was said of Dr. Durand that he was "in his profession a versatile and creative engineer; among his colleagues a wise and friendly counsellor; before his students a kindly and inspiring teacher; to the nation a devoted and able servant."

In 1945, the American Society of Mechanical Engineers, which Dr. Durand has served in many capacities during his active membership of more than 67 years and of which he is a past president and honorary member, awarded him its gold medal. In this citation, the wording was "for his contributions in hydrodynamic and aerodynamic science and its practical application, for his inspiring character and his unique capacity for lucidity and simplicity in imparting highly technical material, for his trustworthy advice to our government in the solution of many intricate problems in peace and during two world wars."

The award in 1948 of the Medal for Merit, the highest honor the United States Government can confer on a civilian, was made by General Spaatz, Chief of Staff, U.S. Air Force, who flew to the West Coast to represent the President of the United States in presentation ceremonies. This medal was accompanied by a citation signed by President Truman, commending Dr. Durand

(*Continued on page 15*)



Dr. William F. Durand receiving congratulations from Lt. Gen. Ira C. Eaker, Deputy Commander, U.S. Air Forces, at the time Dr. Durand received the A.S.M.E. Medal in 1945, "in recognition of his work in forwarding the design and application of principles of jet propulsion" and for his "effective leadership" in the National Research Council.

The Air Force Procurement and Expansion Program

By

JOHN A. McCONE

Under Secretary for the Air Force

Dinner Address Delivered at Flight Propulsion Meeting, March 16, Cleveland

"AT THE CLOSE OF WORLD WAR II, the Air Force was an institution of some 2,250,000 men organized into well in excess of 250 groups and all of their supporting and training organizations. We had carried the war successfully to the enemy. We and the air arm of the Navy had won complete command of the air in both great theaters of war and, in conjunction with the Navy, were supporting the remarkable progress of the Allied ground forces against crumbling but still tenacious opposition.

"Following victory came a great demobilization, and I will not deal with that unfortunate period in our history. You are all familiar with the rapid decrease in the strength of the Air Force and, for that matter, the strength of each arm of the Military Establishment, caused largely by a confidence on the part of the people that a victory had been won which in itself would secure the peace of tomorrow and also by a desire on the part of the people to turn to the peaceful and pleasant occupations of life.

"Despite warnings, despite the ominous signs of real dangers ahead which began to appear on the horizon at the very time the Armistice was being negotiated, we as a people permitted our military power to be dissipated, our great forces demobilized, and a substantial portion of our usable military equipment destroyed or otherwise disposed of.

"No single group can be criticized for these events. Looking in retrospect, we can regret them and sometimes wonder just how we allowed them to happen. But few are the men who can say—in all honesty—that they held in their hearts—in those early postwar days—a deep conviction that we must maintain a great military stature and alertness at all times.

"There are bright sides to this rather unfortunate story, however. With demobilization, regrettable as it now appears, came the philosophy of unification, and through it and through enumerable other management changes came an efficiency that I am sure would not now exist in the Military Establishment were it not for the years of comparatively modest appropriations and the need for getting along with considerably less than seemed necessary at the time to the military leaders. Little satisfaction can be taken from this somewhat obscure fact; nevertheless, one must look at the bright side as well as the dark side of any picture. Therefore, I maintain, without defending in any way the policies of the years of which I speak, that some benefits accrued.

"Of greater importance, however, than all of this is the fact that during these years great progress has been made in the art and science of flight, and here I believe the nation owes a debt of gratitude to you men and women who are sitting in this room whose intelligent effort and great energy have been responsible for the enormous advances in the aircraft engines which make possible such radical improvements in flight.

"Returning to the Air Force program, I wish to recall to you that in the Spring of 1950 the Air Force had been reduced to approximately 48 groups and about 410,000 officers and men. These groups were better equipped than the slightly larger Air Force of 2 years previous, but they were woefully inadequate to meet their responsibilities should they be called into action.

"Then, in June, the Korean incident caused an awakening in this country. An incident over which we had absolutely no control obliged us as part of the

United Nations to respond militarily against an aggressor. We were fortunate that the incident occurred in an area where the United States at least had forces deployed which could be brought into action in a minimum of time. Had the incident occurred at any of several other potential trouble spots in the world, our course of action would have been infinitely less effective, even though there were tragic reverses in the early days in Korea.

"But all of this brought to the American people a realization of two important points: first, that there existed in the world a potential enemy who would resort to military aggression to gain his objective and, second, a realization that this country and our friends in Western Europe and in other parts of the world were not adequately prepared to meet aggression.

"In only a few days, plans for the increase of our military stature, which had long been in preparation by the military authorities, were set in motion by Executive and Congressional order.

"One program after another evolved in the months following Korea as we appraised our position in the world with relation to our enemies, who were then demonstrating the true intent of their aggressive policies. Finally, in December, after the Chinese Communists had entered Korea equipped with Russian weapons, it became apparent that no time could be spared in completing our plans. The President declared a National Emergency and ordered a Military Establishment of 3,500,000 men to be in existence as soon as possible.

"The Air Force, inconsonance with a 3,500,000-man establishment and designed to carry out its functions, calls for something in the order of 95 wings. They cannot be the wings of the pre-Korea days, nor can they be the wings of 2 years ago. Every wing must be completely equipped with the most modern planes now available, and every pilot and bombardier must be trained for action should he be called upon without warning to take to the air in battle.

"The responsibilities of the Air Force under missions assigned to it call for both adequacy and perfection in four areas. I wish to treat each separately and to discuss briefly the equipment planned for each mission.

"First, of course, is the air defense of our country and its possessions and its properties wherever they are. Today for the first time in many many years, the peoples of this country are rightfully concerned over the damaging effect of an attack upon our homeland. It appears to be true that a potential enemy possesses at the present time some considerable capacity for such an attack, and it is equally true that, if that potential enemy devotes his technical and manufacturing resources to expanding his capacity for such an attack, he can, within a short period of years, possess the power to inflict great and serious damage upon us.

"The Air Force will meet this challenge with a vastly improved radar early-warning network now being installed and constantly being improved. In conjunction with this system will be the F-86 interceptor fighter and the F-94 and F-89 all-weather fighters, each designed to climb to great altitudes in a matter of minutes and to seek out and to destroy attacking bombers by day and by night, in good weather and in bad. All of these will be jet fighters, and each will call for ever increasing power or thrust as the requirements of this mission increase. But the need for additional power must be balanced against the practical limitations of fuel consumption and physical dimensions, and therefore the Air Force in developing its program for interceptor fighters must always delicately balance the advantages of increased power against the obvious disadvantages of size, weight, and fuel.

"We look to the men in this room to answer this problem by improvements in engine efficiency, by advances in metallurgy, and by a multitude of other developments that will permit more power with less fuel. I will say that the Air Force as a matter of policy has supported and will continue to support, financially and in every other practical way within our means, the constructive research and development that you gentlemen are advancing in these important fields.

"Looking further into the future, we see, with hope, radar systems that will ensure us against sneak attacks by detecting low-level approaches. We also hope that the advances in the interceptor plane and the guided missile, which can be fired from ground to air and directed by radar and other mechanisms so as to destroy the incoming bomber, will in themselves enormously improve our defense capabilities (if not give us an absolute defense).

"I would be less than frank with you if I did not point out that our present system is far from absolute and that if we were attacked today—or any time in the near future—many bombers would be intercepted but many would get through. It is my personal belief that, with proper application of research and development, our air defense systems will improve more rapidly than the capacity of a potential enemy to attack us and to sustain his attack, and, while I believe there will always be a danger, nevertheless I am confident that our security will improve with the passage of time.

"Second, let me turn to the problems of the tactical support of our ground forces. Much has been written on this subject in recent months because of the thought that has been given to it in connection with the Korean campaign. The Air Force believes that Korea has proved beyond doubt the suitability of the jet as the proper fighting plane for tactical support. Because of the world-wide deployment of our Air Force, we were initially forced to use F-80 interceptors as fighter bombers, a use for which they were not designed. Nevertheless, the result of thousands and thousands of missions have proved that the jet, because of its speed, its stability, and its ruggedness, is to be the tactical support plane of tomorrow. The engine experiences in Korea have been highly satisfactory. Expecting engine changes after 50 or 75 hours of operation, we find that 100 or 150 hours between changes is routine, and some engines have operated satisfactorily up to 300 hours. Both the plane and the engine have proved themselves

to be rugged. They have resisted enormous amounts of ground fire, and time and again they have come home 'on a wing and a prayer' to be hastily repaired and patched up and returned to the battle.

"Our tactical support plane is the F-84, designed to carry large numbers of rockets or bombs and to stay in the air the maximum time. These planes are now being produced in quantity, and the quantities will increase until the units are filled and a proper reserve of planes is established. Also, the F-84 is being supplied in quantity to our friends in Western Europe under the Military Aid Program. This plane possesses all of the qualities necessary for proper tactical support. It will be produced in at least two plants in the United States, and the engine also will come from two sources of supply.

"A light bomber of British design, known as the Canberra, considerably larger and more powerful than the F-84, is also to be used by the Air Force and by the Western European countries as a tactical support plane. This plane, though not so fast as the American-designed B-51 and B-45 fighter bombers, has a distinct advantage of maneuverability and can be operated from smaller fields close behind the lines. Therefore, it was selected after a careful examination of all designs.

"Just as in the interceptor, the Air Force looks to greater power for our tactical support plane, but here again we must balance power against fuel for obvious reasons, and you gentlemen must accept the challenge of developing improved efficiency as a means of answering this problem for us.

"Third, we turn to the mission of the Strategic Striking Force. This, in the opinion of the Air Force, is the handmaiden of our air defense system, for it is our opinion that the best defense is a strong and devastating counter-offensive. We intend to develop and improve continuously our present very considerable capacity in this area. Today, if this country is attacked or if our friends whom we are so energetically helping in the interests of ensuring peace in the world are attacked, the first and most effective military force that can be brought to bear, and will be brought to bear, upon the enemy will be the devastating power of our Strategic Air Force. Today, this force is built around the B-36 as a heavy long-range intercontinental bomber, which is now being produced in substantial numbers, and the B-50 as a medium-range bomber. Both of these great airplanes are now operating with a high degree of efficiency, and while there is always room for improvement in the performance of any airplane, I must say that after having examined the performance of both of these ships I am gratified indeed with the results.

"But we cannot afford to be satisfied. The Air Force therefore has recently ordered the production of the new revolutionary B-52. It is a truly intercontinental jet bomber, the prototype of which will be flying within a few months, and, while the prototype tests are under way, production of B-52's for unit equipment will be started.

"Also, the Air Force is producing in quantity a medium jet bomber known as the B-47, which will in a matter of a few months start to replace the B-50.

"These airplanes will exceed the speeds of the existing bombers by hundreds of miles per hour, will fly at much greater altitudes, will equal both with regard to load-carrying capacity, and will have acceptable range.

"The B-47 is to be produced in three plants by three separate manufacturers. Initially, the B-52 will be produced in one plant, with plans made to bring in a second plant at a later date.

"All here are familiar with the engine requirements of the large bombers. It is because of these requirements that the Air Force supported the development of several engines in the 9,000–12,000-lb. thrust class 2 years ago. I am happy to report to you that at least two of these engines have successfully passed their tests and are either in production or are ready for production.

"With our bombers, more than with any other planes, our concern is specific fuel consumption. Obviously, the range of the airplane is directly affected by the economy of the engine, and therefore it is the practice of the Air Force in evaluating engines to give heavy weight to improvements in fuel consumption.

"The fourth mission of the Air Force is that of transport. Here we must accept the challenge to supply and back up not only the Air Force but also the Army and the Navy. We must be prepared to deploy troops to any part of the world at any time, but we must do more than this. These troops must have their equipment, and the moving of the heavy guns and tanks of a modern Army is a matter of constant concern to the Air Force.

"In World War II, the four-engined C-54 and the two-engined C-47 were the work horses of the Air Transport Command. Today the bigger, faster Fairchild Packets, the Boeing Stratofreighters, and the Douglas Globemasters are the backbone of our Air Transport System. Each is designed to carry large quantities of military equipment or men and to permit the loading and unloading of this equipment with dispatch.

"However, these planes, large as they are and powered with the most powerful reciprocating engines, do not have the capacity to lift our heavy tanks and largest guns. We are therefore turning our attention to larger power plants that will give these planes greater capacity.

"We feel that the 4360 engine with its 3,500 hp. about reaches the upper limit of the piston engine. I do not mean to infer that the piston engine is through, for it will be used in military planes and in commercial planes of many types for years and years to come. However, in reaching for higher horsepower necessary to propel the larger transports, we must turn to the turboprop. Development in this field has been slow because of the technical difficulties in the engine itself and the limitations of the propeller. However, both of

these problems are being overcome, and we look forward to great fleets of transport planes and, indeed, perhaps long-range bombers powered with turboprops of great horsepower and high efficiency. Here again, as in the case of the bomber, unit fuel consumption is of paramount importance, and the success of the application of the turboprop to the plane of tomorrow, after the mechanical problems I have mentioned have been satisfactorily answered, will be dependent upon improvements in the efficiency of this type of engine.

"All of these things are costing you, as taxpayers, an enormous amount of money, but they are all necessary. The challenge is to produce the things that are needed as economically and as efficiently as possible, but in planning production we must always plan not only for the needs of today but for the possibilities of even greater requirements should world conditions deteriorate. Therefore, the Air Force as a matter of policy is establishing multiple lines for all of its requirements and is deliberately overtooling its plants so that it will, if called upon, be able to produce even greater quantities of planes and engines and components than our current needs call for—and do so within a very short time.

"I cannot leave a discussion of this subject without mentioning two points, both of which give us greatest concern, and it is to you, to the gentlemen in this room, that we look for a solution of the problem involved.

"The first is the consumption of critical materials by these new and complex high-powered engines. Already the program of the Air Force and the Navy, which we realize is only getting under way, will preempt practically the entire supply of such important materials as cobalt and columbium. As our program expands, we face the rather dismal prospect of accepting engines of less than desired efficiency and power because of compromises in design which must be made because of lack of these essential materials.

"Ways and means can be found to minimize, if not eliminate, this problem. Today, in passing through the wonderful propulsion laboratories of the N.A.C.A., I saw evidences of great and constructive work in this field. I assure you that the Air Force, as a matter of policy, will support to the limit of its resources the research and development directed toward economies of critical materials in engine construction.

"The second point is a matter of producibility. A rather simple engine of a type of which our program calls for many many thousands is now costing $30,000 to $40,000 and $50,000 each. Analysis of manufacturing costs indicate an extremely high labor content and for that reason a high cost. Ways must be found to design engines for economical manufacture. And we must do more than this. We must design machine tools and develop manufacturing processes that will reduce manhours. This I am sure can and will be done, but it must be done promptly, and no effort should be spared by the engineers and the manufacturers in accomplishing this desired result.

"I have broadly outlined for you the plans of the Air Force to build and to maintain an establishment to operate as part of a 3,500,000-man Military Establishment. This will be a formidable force indeed.

"Such a force is not, however, designed for war. The philosophy behind the plan is the building of a force for peace, and I feel confident as I stand before you, despite the ominous signs from the other side of the world, that a strong alert America will help preserve the peace for years to come. I feel confident that the sacrifices that our boys are making in giving up their careers and their way of life to enter the services and to become part of this great organization will prove the means of avoiding the catastrophe of war because those who command the forces of aggression will not dare to unleash them.

"I do not mean to intimate that all of this might be done in a short time, for we may have to maintain a military stature of the proportions I have mentioned for your lifetime and mine, and the bill will be costly to the American people. But to me it is the great and only insurance against catastrophe, and for that reason I believe it must be supported without reservation by every individual in the land.

Guest Editorial (*Continued from page 11*)

for able, unselfish devotion and "exceptionally meritorious conduct in the performance of outstanding service to the United States." This he did, the citation continues, "without compensation, extraordinarily and with distinction, from 1941 to 1945 as a member of the National Advisory Committee for Aeronautics; chairman, NACA subcommittee on jet and turbine power plants; chairman, division of engineering and industrial research, National Research Council, and member of various committees of the National Academy of Sciences."

In 1949, Dr. Durand received one more award of which his modest nature impelled him to say, as though with relief, "This will be the very last." This was the Wright Brothers Trophy, a replica of the biplane flown by the Wright Brothers at Kitty Hawk in 1903, mounted on a granite block taken from the site where the flight was made.

This award was presented to Dr. Durand "for significant public service of enduring value to aviation in the United States." The trophy was accompanied by a citation from the Chairman of the N.A.C.A., listing what were considered to be the ten most notable achievements of Dr. Durand's lifetime of service.

These achievements stand, in their many ramifications, as an inspiration to all men, especially to those approaching retirement, which Dr. Durand has proved can be a period of golden opportunity for making the highest use of a lifetime of experience. In such a program, retirement ushers in the best years of all.

Closed-Circuit Oil System for Turbojet and Turboprop Aircraft Engines*†

P. H. SCHWEITZER‡

The Pennsylvania State College

ALTITUDE AFFECTS THE LUBRICATION of an engine in two ways—by foaming of the oil and by incomplete filling of the oil pump—both manifesting themselves by a loss in oil pressure. Above 40,000 ft. altitude, the oil pressure frequently drops to less than one-half of its normal value; above 50,000 ft., next to zero. The conventional lubrication system becomes inadequate in such altitudes.

Evidence indicates that the simplest and most effective remedy is the "closed-circuit lubrication system," which is also known as the "S-S system."[1] With only a slight alteration in the circuit and with no moving parts added, the closed circuit system adds approximately 30,000 ft. to the lubrication ceiling.

The conventional dry sump lubrication system is shown schematically in Fig. 1. The pressure pump takes suction from the oil tank and supplies the engine with oil. The oil, after leaving the engine bearings, drains to one or more small sumps, from which it is picked up by one or more scavenge pumps. The scavenge pump transfers the oil through a cooler back to the tank. In order to keep the engine sump dry, the scavenge capacity is made two to six times greater than the pressure pump capacity; hence, air (or gas) is also picked up at the sump, most of which escapes in the oil tank. The greater the excess capacity of the scavenge pump, the greater the aeration of the oil.

In high altitudes the barometric pressure drops to such a low level that the filling of the pressure pump becomes incomplete. The aeration of the oil also becomes aggravated at high altitude. As a result, the oil delivery diminishes and almost disappears above 50,000 ft. altitude.

The most successful methods in raising the lubrication ceiling put positive pressure on the pressure pump inlet and so "supercharge" the pressure pump. This may be accomplished by a pressurized tank, a booster pump, or by the closed-circuit (S-S) system. As yet, none of these solutions has received a wide acceptance, but the closed-circuit system gave such a good account of itself in laboratory and flight tests that it deserves serious consideration.

Presented at the Aircraft Lubrication Symposium, September 26, 1950, State College, Pa.

* The experimental work reported herein was conducted by J. J. DeCarolis, Assistant Professor, and F. A. Hoffman, Jr., Research Assistant, The Pennsylvania State College.

† Tests show the closed-circuit lubrication system fit for 70,000 ft. altitude.

‡ Professor of Engineering Research.

The closed-circuit system as applied to a turbine engine is shown in Fig. 2. The main idea is the use of the scavenge pump as a booster to the pressure pump. In this way the need of an extra booster pump is eliminated. The scavenge pump forces the oil through the oil cooler into the pressure pump with sufficient pressure to ensure adequate filling.

If the engine would never consume or lose any oil, this would be all that would be necessary. However, provision must be made for make-up to replace oil consumed or lost. This is accomplished by connecting a "make-up tank" to the side outlet of an "eductor" or ejector placed between the oil cooler and the pressure pump. The eductor will keep the circuit full of oil by sucking in fresh oil from the make-up tank the moment the circuit loses oil for any reason.

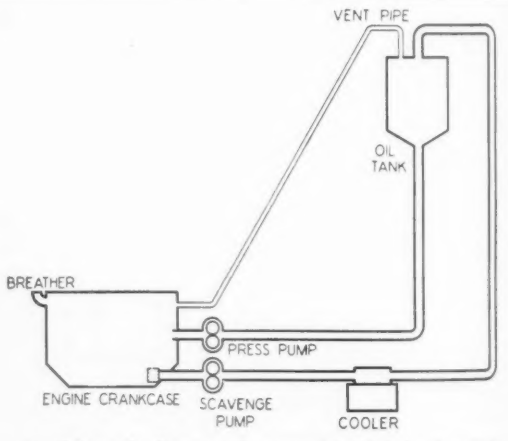


FIG. 1. Schematic diagram of conventional lubrication system.

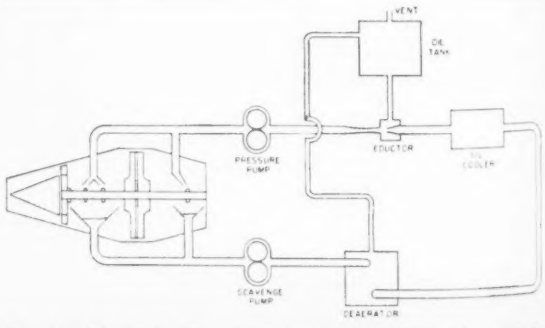


FIG. 2. Schematic diagram of closed-circuit lubrication system.

The eductor, Fig. 3, is a venturi with a side connection at the throat region. The depression at the throat produces a suction until the suction becomes satisfied by getting filled up with make-up oil. In the process the discharge pressure of the eductor and the pressure level of the whole circuit is boosted to, say, 5 lbs. per sq.in. This involves some compression and absorption of entrained air by the oil in the circuit. If, now, some oil is removed form the circuit, the pressure level in the circuit and in the eductor throat will drop (more air is being sucked in by the scavenge pump). The partial vacuum produced at the eductor side outlet then sucks oil from the make-up tank and restores the equilibrium.

However, to make the system operative one more component is necessary: a deaerator between the scavenge pump and the eductor. The deaerator (Fig. 4), a small oil tank with tangential inlet and outlet and a small vent line, removes most of the air from the air-oil mixture delivered by the scavenge pump. In the float-valve-type deaerator the air vent closes when the oil level is high in the deaerator and prevents oil flow to the make-up tank. If the deaerator were absent, air would constantly escape in the eductor through the side outlet and oppose the flow of make-up oil from the make-up tank to the eductor.

As seen, the closed-circuit system is not strictly a closed circuit. The circuit is open by a small opening of the deaerator vent and by the side outlet of the eductor, both of which communicate to the make-up tank. But the boost pressure does not get lost through these openings. The deaerator vent is too small to lose much pressure through it, and the eductor side outlet is placed at the throat of a venturi which tends to create suction.

The maintenance of the equilibrium in the system is completely automatic, and it refuses to get upset even under most severe provocation. When there is a call for more oil, the make-up is prompt and requires no attention by the operator. The closed-circuit system is simple and rugged (no moving parts added), and the following advantages are claimed for it:

(1) It raises the lubrication ceiling by approximately 30,000 ft.

(2) It allows more freedom in the location of the oil tank.

(3) Diluent for take-off can be introduced without diluting the oil in the tank, and no hopper is necessary.

(4) The oil aeration decreases rapidly with increasing altitude.

One may add that these claims have been proved in extended laboratory and flight tests.

In the following, some significant test results will be presented. This series differs from those previously reported on in the following circumstances:

(1) The oil was heated (up to 220°F.) after leaving the pressure pump and was cooled to 100°F. after leaving the deaerator.

(2) Thin oils of the type specified for turbojet and turboprop engines were used.

(3) The scavenge pump to pressure pump capacity ratios were increased from 1.5:1 to 2:1, 4:1, and 6:1 as being more typical of the installations in turbine engines with a multiplicity of scavenge pumps.

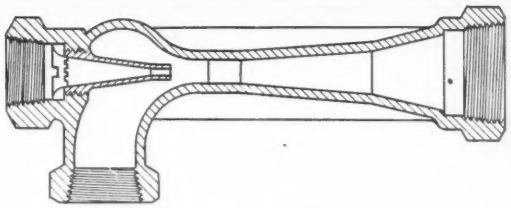


FIG. 3. Eductor.

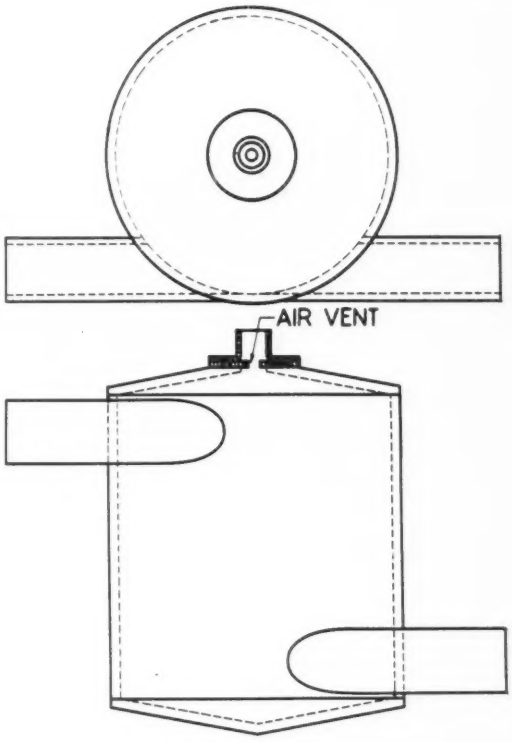


FIG. 4. Deaerator.

(4) The tests were extended to 60,000 ft. simulated altitude, and several tries were made at 70,000 ft. simulated altitude.

Fig. 5 presents typical performance curves for the closed-circuit system. The most relevant factors are plotted against altitude, up to 60,000 ft. The top curve shows the oil rate or circulation expressed in pounds per minute. It can be seen that there is no fall-off at elevated altitudes; on the contrary, there is a slight increase in the oil rate above 25,000 ft. The next lower curve shows the outlet pressure of the pressure pump in pounds per square inch absolute, while the curve below shows the same in gage pressure as it would appear on the pilot's instrument board. The inlet pressure of the pressure pump is seen to drop from 21 lbs. per sq.in. absolute at sea level to 9 lbs. per sq.in. absolute at 60,000 ft. altitude. In the conventional system where the inlet pressure is supplied solely by the barometric

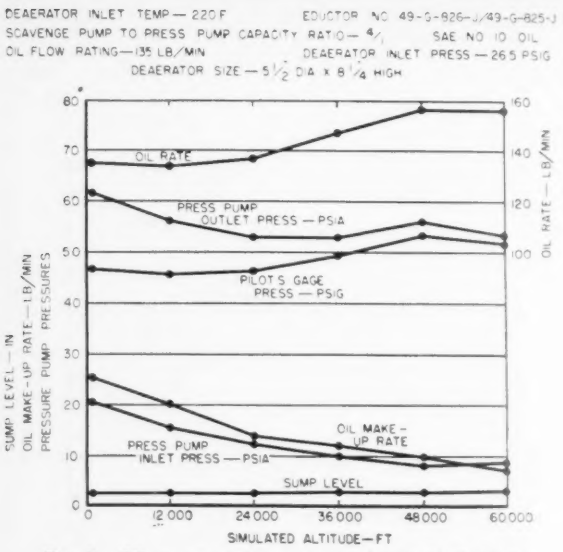

DEAERATOR INLET TEMP — 220 F
EDUCTOR NO. 49-G-826-J/49-G-825-J
SCAVENGE PUMP TO PRESS. PUMP CAPACITY RATIO — 4/1
SAE NO. 10 OIL
OIL FLOW RATING — 135 LB/MIN
DEAERATOR INLET PRESS — 26.5 PSIG
DEAERATOR SIZE — 5 1/2 DIA X 8 1/4 HIGH
OIL RATE
PRESS. PUMP OUTLET PRESS — PSIA
PILOT'S GAGE PRESS — PSIG
OIL MAKE-UP RATE
PRESS. PUMP INLET PRESS — PSIA
SUMP LEVEL
SUMP LEVEL — IN
OIL MAKE-UP RATE — LB/MIN
PRESSURE PUMP PRESSURES
OIL RATE — LB/MIN
SIMULATED ALTITUDE — FT

FIG. 5. Oil system performance vs. simulated altitude.

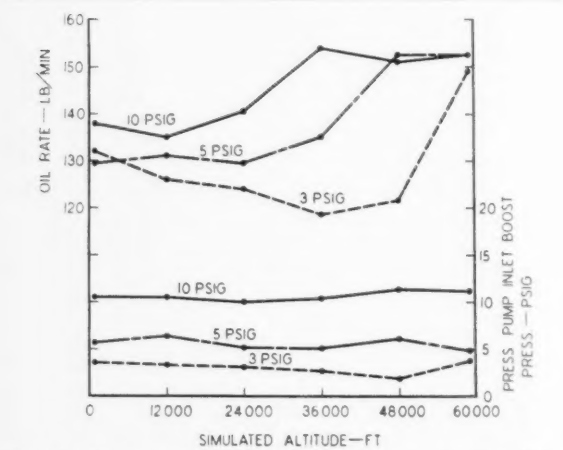


FIG. 6. Oil rate and pressure pump inlet pressure vs. simulated altitude for various nominal eductor boost pressures.

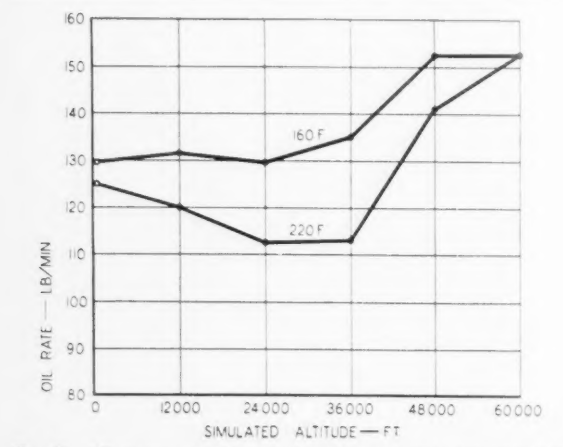


FIG. 7. Oil rate vs. simulated altitude for various deaerator inlet oil temperatures.

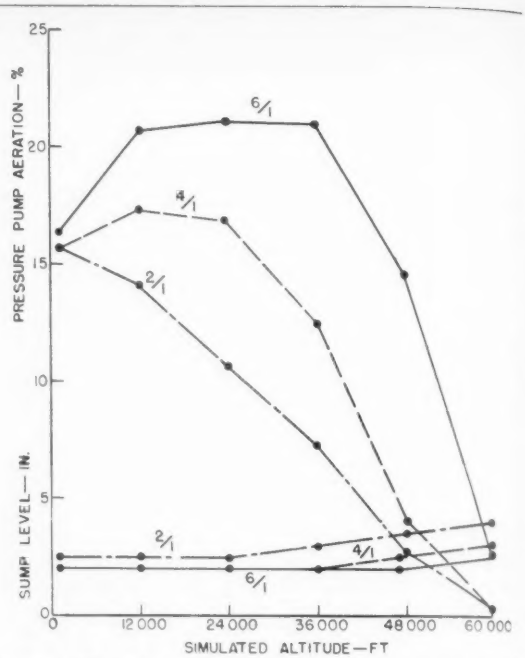


FIG. 8. Effect of scavenge pump to pressure pump capacity ratios on pressure pump aeration and sump level.

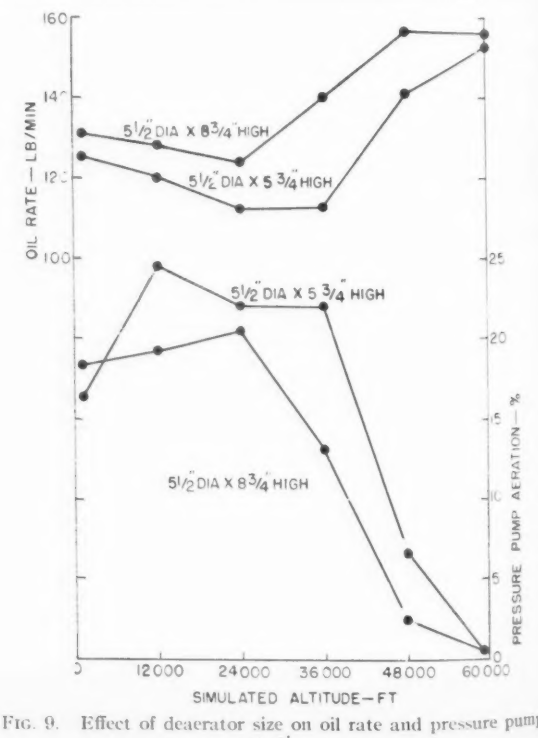

5 1/2" DIA X 8 3/4" HIGH
5 1/2" DIA X 5 3/4" HIGH
5 1/2" DIA X 5 3/4" HIGH
5 1/2" DIA X 8 3/4" HIGH
OIL RATE — LB/MIN
PRESSURE PUMP AERATION — %
SIMULATED ALTITUDE — FT

FIG. 9. Effect of deaerator size on oil rate and pressure pump aeration.

pressure and gravity, it would have dropped to approximately 1 lb. per sq.in. absolute at 60,000 ft.

A curve is marked "oil make-up rate." That shows how promptly the system makes up for lost oil and may be thought of as the stability of the system. If the make-up rate is low, the system has less stability, and, if the make-up rate drops to zero, the system loses stability. That may happen, for instance, if the deaerator is inadequate, causing air to escape through the eductor side outlet. It would also happen if the altitude were so high that the vacuum produced by the eductor were insufficient to depress the side outlet pressure below that of the ambient atmosphere. This did not happen even up to 70,000 ft. altitude.

The lowest line shows the sump level. The significance of this is that, if the altitude is so high that scavenge pump becomes inadequate, the sump level would rise. This did not happen with a 4:1 pump-capacity ratio up to 70,000 ft., but, with lower capacity ratios, pressurization of the engine sumps may be necessary to prevent spilling.

Other readings not plotted on this curve sheet relate to oil aeration, oil drag, deaerator pressure, and others. Those readings and quantities derived from them furnish useful information for the analysis of imperfect oil systems, but, if the curves shown in Fig. 5 indicate that the oil system functions properly, there is no need to worry about them.

Fig. 6 shows the effect of eductor boost pressure upon the inlet boost pressure of the pressure pump and upon the oil rate. It is seen that the boost effect of a given eductor is virtually independent of the altitude. Five pounds of boost was found to satisfy best all requirements up to 70,000 ft. altitude. If the boost is much higher, the make-up rate suffers because of the increased pressure in the venturi throat. If it is much lower, the oil rate decreases with altitude.

The effect of oil temperature upon the oil rate is shown in Fig. 7. The performance is not quite so good with 220°F. oil temperature as with 160°F.

An important factor is the capacity ratio between the scavenge pumps and the pressure pump, as shown on Fig. 8. The oil rate is higher with low ratios, but at 2:1 ratio the sump level rises noticeably. The reason is, of course, the inability of the scavenge pump to keep the sump dry because of its incomplete filling at extremely low ambient pressure. The 6:1 ratio, on the other hand, produces higher aeration, which may adversely affect the make-up rate. A ratio of about 4:1 between the total capacity of the scavenge pumps and the pressure pump is generally the best.

While we are speaking of the scavenge pump, I wish to make an observation on the pump speed. I have noticed speeds of 4,000–5,000 r.p.m. for the scavenge pump. The designer probably used the high speed in order to increase the delivery. That is a mistake. In altitude the delivery drops with pump speed after a certain point. The optimum pump speed that gives greatest oil delivery is generally below 3,000 r.p.m. in

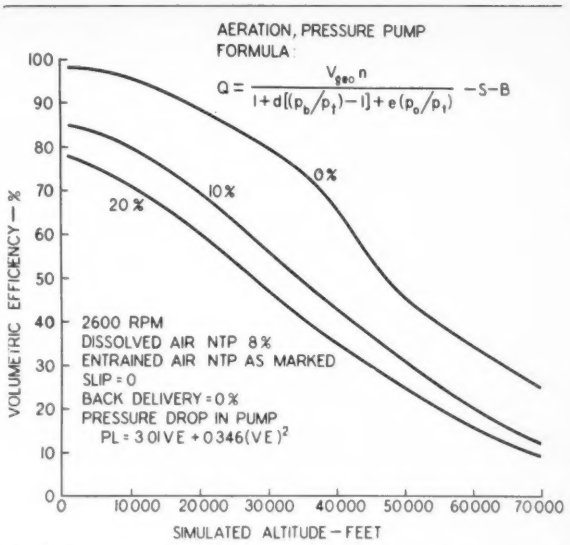


FIG. 10. Calculated volumetric efficiency of gear pumps with various aerations.

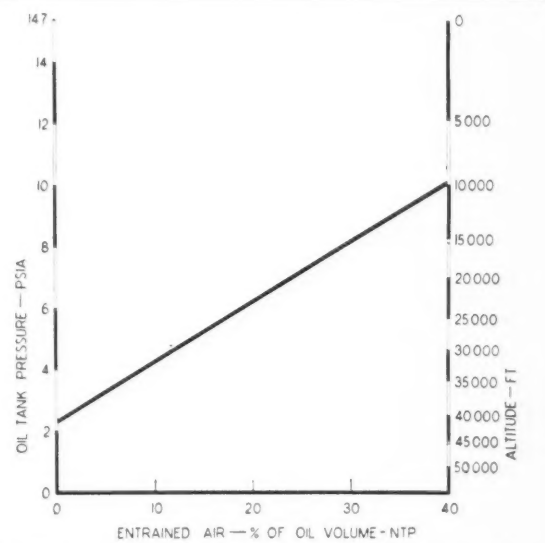


FIG. 11. Required tank pressures to provide minimum lubrication.

altitude. Higher pump speeds do only harm and no good.

The most important effects of the deaerator are shown in Fig. 9. If the deaerator is inadequate, the aeration goes up, and the make-up rate goes down for the reason mentioned above. For 135 lbs. per min. flow, a deaerator of $5^1/_2$ in. diameter by 8 in. is ample for the turboprop engines, and a somewhat larger size for the thinner oil is used in turbojet engines. For larger or smaller flow the dimensions should be changed in proportion to keep the settling rate the same.

It may appear surprising that with the closed-circuit system the oil delivery does not fall off with altitude;

(*Continued on page 82*)

Fatigue Problems in Transport Aircraft*

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ABSTRACT

This paper presents factual information concerning operating times of modern transport aircraft and the incidence of fatigue-type failures in the air frames of such aircraft. It is pointed out that air-frame fatigue failures constitute a serious nuisance but, because of the vigilance of our air-line operators and aircraft manufacturers, usually do not offer a serious threat to airworthiness. The Civil Air Regulations and International Regulations pertaining to fatigue are discussed, together with the administration of these regulations. Some of the types of fatigue problems occurring in service and the corrective and preventive measures taken are also discussed. The conclusions are reached that fatigue failure incidents can best be reduced by increased attention to detail design and improved structural analyses (static and dynamic) and that preventive maintenance is an available and effective means of assuring continued safe operation of new- and old-type transport aircraft.

INTRODUCTION

FATIGUE PROBLEMS IN RECENT YEARS have been given considerable attention both from the design and research points of view. Fatigue problems, however, are not new in aircraft structures; even the original "Kitty Hawk" airplane, first flow by the Wright brothers in 1903, had its difficulties fatigue-wise. In the early days of aviation, many of the fatigue troubles could be blamed on ignorance of design loads and other necessary facts upon which to base a completely successful design, and even today many gaps still exist in our knowledge. However, experience and research have provided us with means of reducing the seriousness of fatigue failures to the point where these failures are a costly nuisance rather than a serious threat to airworthiness.

CIVIL AND INTERNATIONAL REQUIREMENTS RELATING TO FATIGUE

Since 1944, the Civil Air Regulations have contained the following general requirements:

"The structure should be designed insofar as practicable to avoid points of stress concentration where variable stresses above the fatigue limit are likely to occur in normal service."

In administration of this requirement it has rarely been necessary to require special tests or analytical investigations, since the design practices followed by manufacturers have, in general, been excellent, as shown by the high level of safety achieved with our transports. Some repeated load tests, however, have been conducted for pressurized cabin installations of typical windows, enclosures, doors, and even large cabin sections. These tests serve the extremely useful function of exposing weaknesses that might lead to explosive decompressions or to leaking joints, which in turn would require expensive maintenance and the function of proving the structure from a fatigue point of view. In several cases that are exceptions rather than the rule, manufacturers have conducted overall repeated load tests of large components such as wings. These tests, however, were not required by the Civil Aeronautics Administration, although the tests were closely followed and their results carefully noted.

The airworthiness group of ICAO, the International Civil Aeronautical Organization, established the following proposed international standard, which appears as Section 3.11, "Fatigue Strength," of *Annex 8, Airworthiness of Aircraft:*

"The strength and fabrication of the airplane should be such as to insure that the possibility of disastrous fatigue failure of the airplane structure under repeated loads anticipated in operation is extremely remote during the expected life of the airplane or parts thereof. Where a type of construction is used for which experience is not available to show that compliance with other standards of chapter 3 will insure the strength of the structure under repeated loads, its strength under such loads shall be substantiated by suitable investigations." (NOTE: Chapter 3 of *Annex 8* contains structural load and design standards and is entitled "Structures.")

To date, the administration of this requirement has caused little if any hardship for manufacturers, since the structural configurations employed in transport types certificated as complying with ICAO standards have had close prototypes with excellent and long service records. However, it may be that more emphasis will have to be placed in the future on proving structural components for repeated loading conditions if structural configurations vary considerably from proved prototypes.

Presented at the Air Transport Session, Nineteenth Annual Meeting, I.A.S., New York, January 29–February 1, 1951.

* The opinions expressed in this paper are those of the author and do not necessarily represent the opinions of the Civil Aeronautics Administration.

† Chief, Structures Section.

It has been recommended that the Civil Air Regulations be modified to conform to the somewhat more complete, but still general, ICAO standards, but no specific steps have been taken in this direction or are anticipated in the near future. As indicated in the introduction, the general fatigue problem at present appears more serious from a nuisance than a safety point of view, primarily because of the vigilance of the operators.

Causes of Fatigue Fractures

In general, fatigue fractures of a structural element will occur from repeatedly applied stresses resulting from two types of repeatedly applied loads. The first, and in the past the most troublesome, are vibratory loads. The second, and seemingly slightly more important today, are repeated overall structural loads, such as loads in the structure due to the aircraft striking gusts, maneuver loads, and landing loads. These latter loads, although not necessarily so, are usually associated with long periods of operation of the aircraft and have become more and more important as aircraft design has become stabilized sufficiently to permit extended use in terms of time of certain aircraft types.

Repeated stresses resulting from vibratory loads have been, and will continue to be, a cause of familiar types of fatigue difficulties. Cracked engine mounts, cracked cowlings, and cracked skin in the wake of propellers are all examples of fatigue failures that may be traced to vibratory loads originating from engine and propeller motions. Vibratory loads may be subdivided into two groups, both of which cause troubles—resonant vibration and forced vibrations. It is, of course, difficult in some cases to distinguish clearly between these two cases, but illustrative examples will help establish the points. In the interpretations of early regulations, CAR 04a, it was specified that no unsupported panels exceeding certain dimensions should be used. If the basic dimensions of an unsupported panel exceeded the specified dimensions, the panel would probably have a natural frequency near that of the normal engine r.p.m. and would thus vibrate at a relatively high amplitude when a vibration of proper frequency originating in the engine was encountered. Another illustration of a fracture due to resonance-type loading is cracking of aileron hinges due to a resonant lateral motion of the ailerons on a recent transport type. An illustration of the second type of vibratory failure, the forced type, is the failure of skin panels in the wake of the propeller. Here it is not always sufficient to keep the size of the panel below the minimums that will be needed to prevent resonance. It is often necessary to reduce the panels even further by increasing their supports in order to prevent the frequent though small changes in velocity of the air in the slipstream and the resulting varying aerodynamic loads from producing undesirable skin or skin attachment cracks. In a later part of this paper, examples from new and old aircraft will be outlined to illustrate these and other types of fatigue failures.

It is, of course, difficult to draw a clear line between "vibratory" and "repeated overall" loads, especially when one talks in terms of forced vibratory loads. Actually, overall loads are, in general, forced loads—that is, the structure is forced to deflect by externally applied loads such as landing loads, and stresses are induced by the forced deflections. High frequencies are usually associated with vibratory loads, but probably another definitive term, such as "constant amplitude," should be associated with vibratory loads to define them more clearly for purposes of this paper. Vibratory loads will then be considered as loads of relatively high frequency and constant amplitude. Conversely, "overall" loads will be considered as loads of low frequency and varying amplitude. "Overall" loads can be dynamic in nature and, as in the case of landing wheel spin-up loads, may be oscillatory in nature.

Loads repeatedly applied become important fatigue-wise under two circumstances: (1) if the loads result in high stresses or (2) if they are repeated a great number of times. In other words, fatigue failures may result if large stresses are induced even a small number of times, or fatigue failures may occur at low stress levels if the stresses are repeatedly applied a great number of times. The designer must account for the total time an aircraft will be operated and the distances it will travel, for these together will determine the number of repetitions and intensity of vibratory and overall loads.

Operating Times of Transport Aircraft

Table I contains information on the hours of operation completed and the distances traveled between the years 1939 and 1948 by some of the aircraft types in use today. Several points are of considerable interest in this table. For the aircraft listed, a total of more than 2,027,000,000 miles were flown or more than the equivalent of 800,000 trips across the United States.

Table II shows the life in hours accumulated up to the indicated dates by several aircraft. Your attention is invited to the fact that some DC-3 aircraft still in service have accumulated nearly 46,000 hours. Incidentally, the monthly operation rate for active DC-3 airplanes exceeds 150 hours per month. There are other DC-3's that are known to have even greater total operating hours. Actually, some exceeding 50,000 have been mentioned by certain operators. Our records, Table II, were compiled from the aircraft log books of the specific aircraft listed and should, therefore, be authentic.

Some of the other aircraft listed in Table II have accumulated rather extensive operating lives. The Boeing 307B's, the original Boeing "Stratoliner" until only recently operated in small numbers by Trans World Airlines, have accumulated around 20,000 hours each. Similarly, several of the Boeing 247B's,

TABLE I

TOTAL MILES AND APPROXIMATE HOURS OF OPERATION
DOMESTIC AND TERRITORIAL CERTIFICATED AIR CARRIERS
1939 - 1948
(DATA FROM CIVIL AERONAUTICS BOARD ANNUAL AIRLINE STATISTICS)

Manufacturer Model Approx. Cruising Speed	YEAR	MILES IN MILLIONS - HOURS IN THOUSANDS 1939	1940	1941	1942	1943	1944	1945	1946*	1947*	1948*	GRAND TOTALS
DOUGLAS DC-3 V_c= 170	Miles	35,38	62,66	91,93	93,30	98,68	136,67	201,51	287,61	229,08	203,92	1441,74
	Hours	208.1	374.5	540.8	548.8	580.5	803.9	1,185.4	1,691.8	1,347.5	1,199.5	8480.80
DOUGLAS DC-4 V_c= 200	Miles	- -	- -	- -	- -	- -	- -	- - -	73,61	138,34	135,29	347,24
	Hours	- -	- -	- -	- -	- -	- -	- - -	368.1	691,7	676.5	1736.3
DOUGLAS DC-6 V_c= 300	Miles	- -	- -	- -	- -	- -	- -	- - -	- -	13,80	36,91	50,71
	Hours	- -	- -	- -	- -	- -	- -	- - -	- -	46.0	123.0	169.0
BOEING 247 D V_c= 150	Miles	8,85	5,97	4,90	2,14	,09	- -	- - -	,23	,94	,18	23,70
	Hours	55.0	39.8	32.7	14.3	.6	- -	- - -	1.5	6.3	1.2	151.4
BOEING 307 B V_c= 190	Miles	- -	1,55	2,91	,34	- -	- -	,2,78	4,73	2,91	2,48	17,70
	Hours	- -	8.2	15.3	1.3	- -	- -	14.6	24.9	15.3	13.1	93.20
LOCKHEED Model 18 LODESTAR V_c= 200	Miles	- -	1,00	4,13	2,50	5,82	9,02	9,99	7,73	4,55	1,47	48,33
	Hours	- -	5.3	20.6	22.8	29.1	45.1	50.0	38.7	22.8	7.35	241.75
LOCKHEED Model 49 V_c= 300	Miles	- -	- -	- -	- -	- -	- -	- - -	9,95	31,25	44,98	86,18
	Hours	- -	- -	- -	- -	- -	- -	- - -	33.1	104.2	149.9	287.2
CONVAIR Model 240 V_c= 225	Miles	- -	- -	- -	- -	- -	- -	- - -	- -	- -	6,97	6,97
	Hours	- -	- -	- -	- -	- -	- -	- - -	- -	- -	30,53	30,53
MARTIN Model 202 V_c= 225	Miles	- -	- -	- -	- -	- -	- -	- - -	- -	,58	5,52	6,10
	Hours	- -	- -	- -	- -	- -	- -	- - -	- -	2,57	24,53	27,10
GRAND TOTALS	Miles	43,63	72,24	103,87	100,34	104,59	145,69	211,28	383,86	421,45	437,62	2027,97
	Hours	263.1	427.8	609.4	587.7	610.2	849.0	1,250.0	2,158.1	2,196.27	2,225.01	11417.73

* Scheduled U.S. Certificated International Air Carrier Operations included

TABLE II

TOTAL LOGGED FLYING HOURS
(CIVIL OPERATION)
(STATISTICS OBTAINED FROM AIR CARRIERS)

ITEM	AIRPLANE MODEL	MANUFACTURER	AIRCRAFT NUMBER	DATE LICENSED	DATE OF DATA	TOTAL HOURS AIRFRAME
1	DC-3	Douglas	N16095	12-36	12-50	45861
2	DC-3	"	N17318	6-37	12-50	46111
3	DC-3	"	N16071	11-36	12-50	44836
4	DC-4	Douglas	N88704	MS-9-46	12-50	17175
5	DC-4	"	N88815	MS-7-46	12-50	17104
6	DC-4	"	N88702	MS-8-46	12-50	16967
7	DC-6	Douglas	N90713	4-47	11-50	8309
8	DC-6	"	N90714	5-47	11-50	8244
9	DC-6	"	N90702	11-46	11-50	8185
10	307B-1	Boeing	N1940	2-40	6-48	20507
11	307B-1	"	N19005	6-39	6-48	18408
12	307B-1	"	N19007	5-40	6-48	18004
13	247D	Boeing	N41813	8-33	6-48	18138
14	247D	"	N41814	8-33	6-48	20926
15	247D	"	N41810	9-35	6-48	7066
16	377	Boeing	N1023V	4-48	11-50	4039
17	377	"	N1025V	12-48	11-50	3065
18	377	"	N1026V	2-49	11-50	3703
19	18	Lockheed	N15688	10-40	12-50	25986
20	18	"	N28339	1-41	12-50	28636
21	18	"	N15578	MS-7-43	12-50	22061
22	49	Lockheed	86514	2-46	12-50	13206
23	49	"	86515	2-46	12-50	13161
24	49	"	86506	11-45	12-50	13220
25	202	Martin	N93039	9-47	12-50	6132
26	202	"	N93043	10-47	12-50	6328
27	202	"	N92046	11-47	12-50	6233
28	240	Convair	N94230	4-48	11-50	4370
29	240	"	N94204	3-48	12-50	4192
30	240	"	N94226	4-48	11-50	4127

An active airplane will average more than 150 hours flying per month (WS - war surplus)

TABLE III

FATIGUE DIFFICULTIES NUISANCE CATEGORY

TYPE A

	DESCRIPTION	CAUSE	FLIGHT TIME	CORRECTION
1.	Cracks in upper and lower trailing edge wing and center section skin in vicinity of wing splice.	Vibration Loads	500 - 1,000 Hrs. (Approx.)	Addition of formers on upper T.E. skin to prevent vibration
2.	Cracks and loose rivets in outer wing flap trailing edge skin, and outboard flaps.	Vibration Loads	Less than 1,000 Hrs.	Addition of fiber formers to reinforce T.E. skin
3.	Miscellaneous cracks on nose cowl, flap shutter doors, cowl flaps, nacelle fairings.	Vibration Loads	Less than 1,000 Hrs.	Skin reinforced
4.	Cracks almost 180° around left outboard main gear axle near fillet at axle junction with lower piston tube forging.	Stress Concentration due to tool-mark plus overall loads	545 Hrs.	L/G Reworked and restored to service

the original Boeing clipper ships that were familiar sights on the transoceanic airways before and during World War II, have accumulated around 20,000 hours each. The Lockheed Model 18's, the Lodestar, now being operated by National Airlines, Inc., have accumulated more than 25,000 hours each.

Some of the later aircraft (such as the DC-4, DC-6, the Lockheed Models 49, the Martin 2-0-2, and Convair 240) have not been in service for a sufficient time as yet to accumulate a startling number of hours, but still they have accumulated respectable amounts of time. For example, some of the 2-0-2's and 240's have effectively completed about 1,000,000 miles each or the equivalent of about 400 trips across this country. Your automobile, not to mention yourself, would be weary after so many journeys. The Boeing 377's also, even in their short lives, have accumulated an appreciable record. As indicated in Table II, there are some 377's with as much as 4,000 hours or the equivalent of roughly 500 trips across the country.

From the foregoing discussion, it is clear that the designer of a modern transport type should anticipate that his aircraft will have a useful life exceeding 20,000 hours and will travel great distances. He should account in the design for the large number of landings that will be completed; for the larger number of gusts of different magnitudes which the airplane will encounter; and for the many repetitions of loadings resulting from such factors as landing gear and control actuation, pressurization, vibration, maneuvers, fuel sloshing, and other possible fatigue conditions that will be encountered in the normal operation of the aircraft. The designer, too, will find it necessary to follow the aircraft closely and aggressively as it accumulates service time, for only through correction of unforeseen difficulties as they arise can safe operation of his aircraft be assured.

Fatigue Failures and Accidents

The point made in the previous paragraph concerning length of service of transport aircraft is worth repeating. In a long life there can be many experiences of gusts, landings, and maneuver loads—that is, even if low one-load factor, normal-flight stresses are realized in a design, the large number of occurrences of repeated "overall" loads that will be accumulated in a long life will make it likely that there will be fatigue cracking.

As long as a fatigue crack progresses at a rate that will permit its detection before extensive and dangerous damage occurs, there should be no real fear as to its seriousness from an airworthiness point of view. However, since it is virtually impossible to design to eliminate fatigue cracks completely, some cracking must be expected. The important point is to ensure that either a fatigue failure of the unit will not seriously jeopardize the structural integrity of the aircraft or that the rate of progress of the fracture will permit detection before the structural integrity of the unit is jeopardized. The type of fatigue difficulty that is most serious is the catastrophic type such as failure of a tension member. Two such failures have occurred in air operation since 1938. In both of these instances, a failure of a tension-carrying member in the lower wing surface occurred and the aircraft crashed. These two accidents are, however, the only fatal accidents recorded between 1938 and 1951 of transport aircraft being operated by certificated air carriers in which fatigue failures of the air frames have been judged the actual cause of the accident.

Since 1938 only one other fatal accident to a transport aircraft appears in our records—that of a considerably older type that was being operated by a private owner at the time of the fatal crash. Since this airplane was not being operated by a certificated air carrier, it is felt that little weight should be placed on this accident. Unknowns associated with operation techniques and maintenance techniques on this aircraft would leave a few questions open as to whether the fatigue failure could reasonably have been expected to have been discovered prior to final failure of the structure.

As pointed out, the above failures represent the only cases in which the fatigue failure of the air frame was considered to be the cause of a fatal accident in certificated air carrier operation of transport category aircraft. A total number of flying hours exceeding 11,000,000 or equivalent to more than 2,000,000,000 miles have been completed with only these two fatal failures to mar the record.

There have been many other cases of fatigue difficulties of a less serious nature, and some of these failures have resulted in serious accidents from an aircraft damage point of view. For example, there have been several instances of landing gears either failing to extend or collapsing on contact with the ground, with extensive subsequent damage to the aircraft. Another and a most unusual accident was one in which a partial wheel failure due to a fatigue fracture resulted in extensive damage to the aircraft cabin structure. In this instance, a portion of the wheel flange was thrown into a propeller, which in turn threw it into the side of the fuselage. These accidents, although not resulting in fatalities, were most costly for operators in loss of time, use of equipment, and cost of repairs. The designer must keep the serious possible consequences of a fatigue fracture in mind and guard against this type of failure.

Although there have been quite a few instances of fatigue fractures with relatively serious consequences, by far the majority of fatigue difficulties are of a much less serious nature. The fractures of this larger group are treated as maintenance problems by operators. The normal maintenance procedures followed by operators, supplemented by mandatory inspections and/or replacements where the seriousness of the particular condition may warrant such mandatory action, assure continued safe operation of the aircraft. The expenses involved for the operator in inspecting, repairing, or replacing parts suffering such nuisance-type fractures are

TABLE IV

FATIGUE DIFFICULTIES NUISANCE CATEGORY

TYPE B

DESCRIPTION	CAUSE	FLIGHT TIME	CORRECTION
1. Cracks in trailing edge skin of both wings between rivets.	Vibration Loads	200 Hrs. (Approx.)	Local Repairs
2. Cracks in magnesium rudder skin originating in rivet holes.	Vibration Loads	150 Hrs. (Approx.)	Local Repairs
3. Cracks in aileron hinge brackets	Vibration Loads (Resonance)	100 - 200 Hrs.	Strengthened Stiffined parts installed
4. Cracks in Z stringers and rib flanges and bolt heads pulling through rib flange in integral fuel tank areas.	Overall Loads and Vibration	Cracks Start at 200 Hrs. (Approx.) and progress with increasing flight time.	Shear clips installed on stringer-rib junctions
5. Spar web cracks where main gear actuating hydraulic lines pass through spar webs.	Overall Loads	200 Hrs. (Approx.)	Reinforcing Plates

large and are a most important factor for the designer to consider.

Examples of Nuisance-Type Fatigue Troubles

A typical series of nuisance-type fatigue fractures are listed in Table III. These troubles have occurred on aircraft type A, a recent twin-engined type. The most serious of the troubles listed is the fatigue-cracking of the main gear axle near a fillet; this crack occurred after a little over 500 hours of service on one aircraft. Other aircraft were examined and some additional axles were found to be cracked. The manufacturer, by laboratory tests, isolated the cause of the cracks, and rework of all gears in service was completed. The other cases included in Table III are not serious in themselves and were detected before the structural integrity of the air frame was jeopardized.

The U.S. Navy, Bureau of Aeronautics, recently completed a survey for cracks in the main spar truss in the area adjacent to the landing-gear drag strut attachment of one of their training aircraft that has a civil version. This survey showed that, although 30 per cent had cracks, only about 3 per cent of the airplanes were considered unrepairable, having cracks in critical members, such as the lower spar member on which safety in flight is directly dependent. It has been tentatively established that the relatively frequent and probably severe landings of this training model result in fatigue cracking of the truss. These aircraft have landing gears that have been found to have critical spin-up characteristics, and these characteristics, plus the severe operation, are believed to have been the cause of the difficulties. A fix has been developed and is being incorporated in civil and military versions of this type.

Table IV lists a series of difficulties typical of those experienced with aircraft type B, another modern twin-engined type. In particular, a series of troubles has been experienced with cracking of various tail components and vibration of the controls. These troubles have not been completely explained; however, it appears that the causes were vibration loads originating from fluctuations in velocity of the slipstream or similar fluctuating air loads. It is of considerable interest to note that magnesium alloy was used in the construction of portions of these surfaces. However, there is no apparent reason to believe that any significance can be attached to this fact. There has also been a series of difficulties with wings of this type. The flanges of the wing ribs have been cracking adjacent to the skin, and cracking of other wing parts has been experienced.

In order that a comparison can be made between the newer aircraft and an older aircraft of the same general type, Table V has been prepared and lists some of the difficulties that have been experienced with type C, a twin-engined type having much service experience. It will be noted that quite a few difficulties similar to those of the Models A and B have been experienced by Model C. Early in the operational history of the Model C, cracks began to appear between bolt holes of the outer-wing inner-wing attach angles. It was found, however, that these cracks could readily be detected by inspection because of the accessibility of their location, because of the fact that the crack opened sufficiently to permit easy detection, and because the crack progressed at a slow rate and did not reach dangerous proportions between inspection periods. It was therefore possible to establish inspection and replacement procedures that substantially eliminated the hazard connected with this failure.

There have also been some fatigue fractures in modern four-engined airplanes, types D and E, some of which are listed in Tables VI and VII. The fractures of type D spar webs by cracking are one of the more interesting types of fatigue failure. After much research and testing, it was established that the spar-web fail-

TABLE V

FATIGUE DIFFICULTIES - NUISANCE CATEGORY

TYPE C

DESCRIPTION	CAUSE	FLIGHT TIME	CORRECTION
1. Wing attaching angles, cracks between attaching bolt holes.	Overall plus Vibration Loads	Less than 5,000 Hrs.	New Instructions
2. Doublers, wing attaching angles, cracks along bert up flange.	Overall plus Vibration Loads	Less than 5,000 Hrs.	Improved Unit Treat.
3. Captain's right rudder pedal arm broken at cross tube connection.	Overall Loads	20,000 Hrs.	Replace Part Periodic Inspection.
4. Center Section Skin, Outer wing joint at Lower center spar, Cracks in the Skin.	Vibration Loads	Less than 5,000 Hrs.	Use next Heavier Gage.
5. Outer Aileron Hinge Ribs, Cracks in the Flanges.	Overall Loads	Less than 5,000 Hrs.	Use next Heavier Gage.
6. Vertical Stabilizer Beams, Cracks in the Corner of the Beams Adjacent to the Former.	Overall Loads	Less than 5,000 Hrs.	Use next Heavier Gage.
7. Elevator Ribs at Inboard & Outboard Ends of Trim Tabs Cracks in Webs.	Vibration Loads	Less than 5,000 Hrs.	Increase from .020 to .040.
8. Wing Flap Operating Tube Support Beam Attaching Angles, Cracks in Bend Radii	Overall Loads	Less than 5,000 Hrs.	Redesigned Heavier Sections.

TABLE VI

FATIGUE DIFFICULTIES - MULSANCE CATEGORY

TYPE D

DESCRIPTION	CAUSE	FLIGHT TIME	CORRECTION
1. Spar Webs Integral Tank Area.	Dynamic Loads	Less than 1,000 Hrs.	Added Vertical Stiffeners
2. Nose Wheel Drag Strut Collar. Cracks in Region Where Steering Lug Meets Collar Body.	Overall Loads	3,000 Hrs.	Rework part and add Braces
3. Main Fuel Line Support Brackets at Wing Stas. 257, 272, and 300. Cracks and Parts Broken Off.	Vibration	Less than 1,000 Hrs.	Brackets Redesigned
4. Rudder and Elevator Hinge and Tab Hinge Brackets. Cracks in Corners.	Attaching Bolt Crushing Loads	5,000 Hrs.	Replace part Use Torque Wrench.
5. Nose Gear Yoke Fittings Cracking	Overall Loads	More than 3,000 Hrs.	Rework part Removing tool marks and increasing radii or replace.

ures were due primarily to fuel sloshing and vibratory loads, since it was not possible to reproduce the failures by repeated flexing of the wing in a manner simulating the air-load applications alone. Because this type uses integral tanks for fuel, spar-web cracks resulted in fuel leakage, which in turn led to the quick detection of the cracks. Thus, the inspection of wings for cracked spar webs was considerably simplified by fuel-leakage indications and in no case did a really hazardous condition ever develop.

Remedial and Preventative Measures

The most dangerous type of fracture regardless of cause is the catastrophic-type failure in which an essential load-carrying member fails without warning as a result of a fatigue crack that develops in an unsuspected area or which progresses at a rate too fast to permit detection prior to failure. The catastrophic failure must be guarded against particularly by the designer. He must carefully evaluate his design to eliminate this type of failure. There are several questions that should be considered in such evaluations:

(1) Will failure of the part jeopardize the remaining structure?

(2) Will a fatigue crack be easily detected once it has formed?

(3) Will the rate of progress of the crack be slow enough to assure that an unsafe condition will not develop between inspections?

If the answer to the first question is yes, then the answer to the second and third questions must be yes or the stress level should be kept low enough, consistent with the number of repeated applications of particular stress to be expected during the service life of the airplane, so that the probability of a fatigue failure in service is extremely remote. If the answer to the first question is no, then, although desirable, the answer to the second and third questions need not be yes.

Fatigue fractures will fall into two broad classifications: those caused by overall loads and those caused by vibratory loads. The designer must determine for his particular design which loadings will be critical and use the best tools available to him to assure fatigue strength for these loads. An outstanding engineer in the field of design and analysis of aircraft structures recently stated that methods of analysis for fatigue loading were available which could be relied upon to give conservative predictions of fatigue life where loadings were accurately known. This same individual pointed out that refinements in "static" analyses could also pay dividends in reducing the incidence and seriousness of fatigue failures. The designer now has some analytical procedures at his command, and the research programs under way in this field will supply still further procedures to assist him in solving some of the problems of design for repeatedly applied loads. The designer must then become familiar with these analytical procedures and make full use of them if he is to realize their full benefit in preventing fatigue troubles.

Another highly useful tool for the designer is the repeated load or fatigue test of structural components. Where the designer feels that a check of the fatigue strength of his structure is desirable, he may conduct a repeated load test in his laboratory. The techniques of such tests have been improved greatly over recent years, and this type of test is being used extensively for both development and investigation work. It is often more practical and desirable to conduct a repeated load test of a component than to analyze the component for a given load spectrum. The fatigue test will often disclose unsuspected weaknesses or explain quickly a service failure. Errors or inadequacies in detail design of small elements of large assemblies are often disclosed and possible service troubles are eliminated by such tests—all to the advantage of the designer and operator. Where the loading spectrum is known with reasonable accuracy, the laboratory fatigue tests should be most helpful in reducing the incidence of service fatigue difficulties.

Tables III through VII indicate that the correction of service fatigue troubles in most cases involves a change in the detail design of the part. This, coupled with the fact that detailed analyses of particular troubles almost

TABLE VII

FATIGUE DIFFICULTIES - NUISANCE CATEGORY

TYPE D

DESCRIPTION	CAUSE	FLIGHT TIME	CORRECTION
1. Landing Gear Torque Arms Cracks in Webs at Knee Bolt Positions.	Overall Loads	Less than 1,000 Hrs.	Replaced with Steel Part
2. Main Landing Gear Drag-Link Crosshead. Cracks in Fillet Region.	Overall Loads	Less than 1,000 Hrs.	Replaced with New Part
3. Aileron Inboard of Trim Tab. Cracks in Trailing Edge and in Aft Portion of Ribs.	Vibration	Less than 1,000 Hrs.	Use next heavier Gage Rebalance surface
4. Aileron Leading Edge Ribs Stas. 571, 577. Cracks in Leading Edge Skin and Counter Balance Supports	Vibration	Less than 1,000 Hrs.	Use Next heavier gage rebalance surface
5. Landing Gear Doors Cracking Near Hinges	Vibration	Less than 1,000 Hrs.	Install skin Doublers

invariably reveal that the life of the part could be extended materially by removing stress risers or reducing operating stresses, leads to the contention that maintenance costs could be reduced and safety improved if more attention were paid to detail design in the initial stages of the development of a type. The designer must realize that sharp fillets, small radii, abrupt changes in cross section, holes, etc., all result in local stress concentrations and are thus potential sources of fatigue difficulties. Good design practices, keeping stress risers to a minimum, should be used and will pay large dividends in reducing the incidence of fatigue fractures. Many designers feel that attention to detail design is the most effective single step in reducing fatigue difficulties. The general problem of fatigue is so important, however, that the designer should use the best of analytical procedures, test techniques, and detail design practices to eliminate foreseeable fatigue difficulties and reduce costs of operation of our transport aircraft. Only in this way can we expect the highest level of safety in our transport aircraft.

To facilitate the exchange of information concerning unforeseen mechanical difficulties that arise in service of transport types, the C.A.A., with the close and full cooperation of the operators, has established the Daily Mechanical Report system. Operators encountering a new mechanical difficulty, fatigue difficulties included, report the circumstances to the C.A.A. The C.A.A., after some screening, compiles these, together with reports from C.A.A. agents, into daily summaries of all mechanical difficulties encountered. The C.A.A. then circulates these summaries, with the help of the Air Transport Association, to operators and other groups. Individual operators are thus informed of new difficulties as they arise. This enables them to take steps to correct similar difficulties that might exist in their fleets or to prevent these troubles from occurring. These mechanical reports are also made available to manufacturers for their action where cases warrant action. This exchange of information between operators, the C.A.A., and manufacturers does much to promote better maintenance and safety. An average of a little more than 30 mechanical reports dealing with fatigue troubles are reported each month. Some cases are duplicates of others and some are isolated cases, but most of the cases reported are new and lead to action by the operators and manufacturers.

The aircraft operator is well aware that fatigue troubles do exist and is equally well aware of the powerful procedures at his command with which he can supplement the work of the designer and with which he can assure continued safe operation of both his new- and old-type aircraft. Preventive maintenance, including part replacement, where dictated by experience, will prevent failures and reoccurrence of failures of parts. Regular inspections will disclose incipient troubles in both old and new aircraft, and experience accumulated with older aircraft of a type will be most useful in establishing inspection and replacement procedures for younger aircraft of that type. Progressive sampling type inspection procedures are especially useful for new types and assure safe operation of the type without burdensome routine fleetwide inspection at short intervals as service time accumulates. These tools in the hands of the operator, supplemented by aggressive cooperation between the operator and the manufacturer in preventing incidents of fatigue failure and in establishing the causes and fixes for troubles that do arise, will continue the high level of safety achieved by American air carriers.

I.A.S. National Meeting Schedule

Annual Summer Meeting—Western Headquarters Building, Los Angeles—June 27–28

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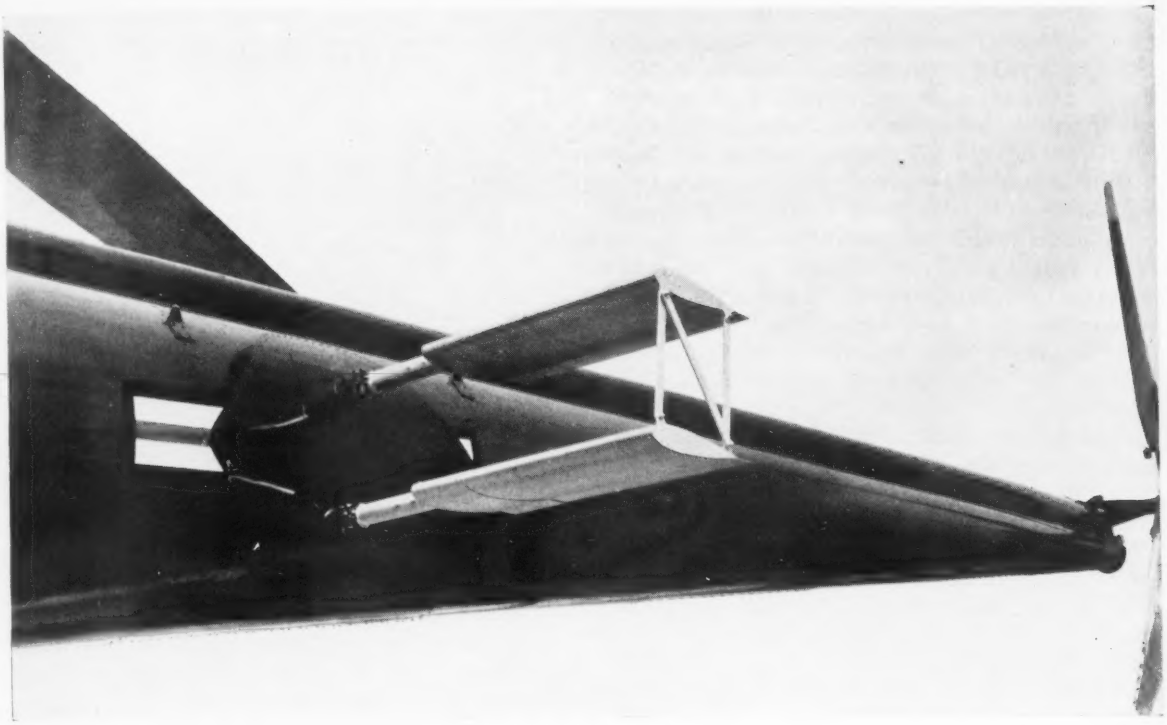

Desirable Longitudinal Flying Qualities for Helicopters and Means to Achieve Them

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SUMMARY

Tentative longitudinal flying qualities requirements for helicopters, based largely on pilot observations and measured stability and control characteristics for several single-rotor helicopters, are given. It was found that pilots are influenced by details of the time-history of normal acceleration following control displacement.

Various means that have been tried or suggested for achieving desirable characteristics are outlined. Experimental results (obtained while varying the characteristics to establish the requirements) showing the effectiveness of two such means are presented. These are (1) increasing the stability with angle of attack by means of a horizontal tail and (2) increasing the damping in pitch of the helicopter by artificial means. It is shown that the characteristics can be varied from unsatisfactory to satisfactory by either means. The effect on initial control response of making the tail surface move with the cyclic pitch control is also shown.

It is pointed out that, in general, the best design practice may be to use several of the methods discussed in combination with one another rather than to rely solely on one method.

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INTRODUCTION

WITHIN THE LAST FEW YEARS, the desire for all-weather helicopter operation has been one of several factors that have caused increasing emphasis on the obtaining of desirable stability and control, or flying and handling qualities, in helicopters. The former expedient of using controllability in place of stability has been abandoned to a great extent, and both vertical-flight and forward-flight characteristics have received attention. The current interest in higher helicopter forward speeds further accentuates the importance of studies of forward-flight flying qualities, since instabilities that are mild at low speeds may become catastrophic at high speeds. In the N.A.C.A.'s evaluation of the helicopter flying qualities problem,[1, 2] the presence or absence of a tendency to diverge in pitch in forward flight has seemed the factor of greatest general concern, although under more special circumstances lateral or directional problems have appeared, as well as problems in hovering and low-speed flight.

To separate this problem of divergence in pitch from other longitudinal items, it is convenient to refer to it as "maneuver stability" to distinguish it from "speed stability." For a helicopter that is stable in maneuvers, a rearward stick displacement must be maintained during a pull-up or steady turn—that is, the stick must stay aft of the original trim position. Maneuver stability is thus similar to angle-of-attack stability but is more general in that damping in pitch is also taken into account. Speed stability, on the other hand, has reference to the fact that, for a helicopter that is stable with speed, to obtain and hold a higher speed the stick must be moved forward and kept forward of its original position; similarly, a lower speed requires a more aft position.

Trials for determining both types of stability are made at fixed collective pitch and throttle settings.

The definitions given could be made to apply to stick forces, as well as stick positions, but, for reasons to be explained later, this paper will concentrate on stick position, or stick-fixed stability, rather than on stick forces or stick-free stability. The term "maneuver qualities" or alternatively "maneuver characteristics" will be used herein as more all-inclusive terms to refer to maneuver stability, details of the initial response to controls, and stick forces—in other words, any or all of the characteristics influencing pilots' opinions of maneuvers.

Speed stability is important in that factors such as periodic blade twist or unstable fuselage moments can lead to catastrophic conditions at high speed. It is also important in that instability with speed results in much more work for the pilot in maintaining steady flight. The simplest form of helicopter rotor is inherently stable with speed, and current regulations or specifications for helicopters generally require flight demonstrations to show that this speed stability is realized.

On the other hand, the simplest form of helicopter rotor is unstable with angle of attack, and, because the damping in pitch of the elementary form of helicopter is low, it is unstable in maneuvers. If no means are employed to prevent the instability, the pilot must constantly make small stick motions to prevent nose-up or nose-down deviations from the intended flight path. In such cases, in high-speed flight the deviation can be so rapid that, if the stick is held fixed for more than a few seconds, dangerous flight conditions will be reached during recovery. It will be evident that this situation is increased in importance by blind flying and by higher helicopter forward speeds.

Although speed stability is now generally required, maneuver stability is not universally required, at least in any specific manner. Presumably, its omission from some requirements means that its meaning, methods of checking for it, and means for obtaining it are not sufficiently understood as yet and that it is therefore felt that specific requirements would retard new developments. The objective of this paper is to clarify the situation sufficiently so that some specific coverage of maneuver qualities can be universally included in helicopter flying qualities requirements.

Desirable Maneuver Characteristics

The first step toward improvement is to determine what qualities are wanted. Tentative maneuver requirements were published in reference 2. The time-history of normal acceleration for a pull-up maneuver appeared on the basis of that study to be the best index of maneuver qualities. The primary reason for the pilot's interest in normal acceleration is that he tries to hold a straight flight path, or one of fixed curvature if in a turn, and a change in normal acceleration indicates a change in curvature of the flight path. At any given speed, flight path curvature and normal acceleration are directly related. It is known that a human being can detect extremely small changes in normal acceleration (0.02g or even less). The relative importance of sensing of normal acceleration in distinction to sensing of attitude angle or pitching-velocity changes will increase with increasing helicopter speeds. (The converse would be true for low speeds and hovering operation, and it should be made clear that forward-flight requirements are the ones considered here.)

Fig. 1 shows three types of pull-up time-histories. To obtain records of this type, the stick is abruptly displaced from trim about 1 in. and held fixed while flying at cruising speed or faster. An acceleration change of about 0.3g to 0.5g is realized in about 2 to 3 sec. When a curve of type (a) is obtained, the helicopter characteristics are considered unsatisfactory and can be dangerous. Type (b) represents removal of the prolonged divergence characteristics shown for type (a). Pilot apprehension is then greatly reduced and the primary danger is removed, but the pilot still has difficulty in anticipating the eventual results of a control deflection soon enough for easy flying because of the misleading nature of the early variations in normal acceleration. With a more reasonable shape at the start of the curve, removing most of the pause or flat spot as in type (c), the pilot is completely satisfied. For typical maximum values, the change in shape from type (b) to type (c) often represents only a few hundredths of one $\bar{g}$ difference in acceleration values at any given time, yet pilots

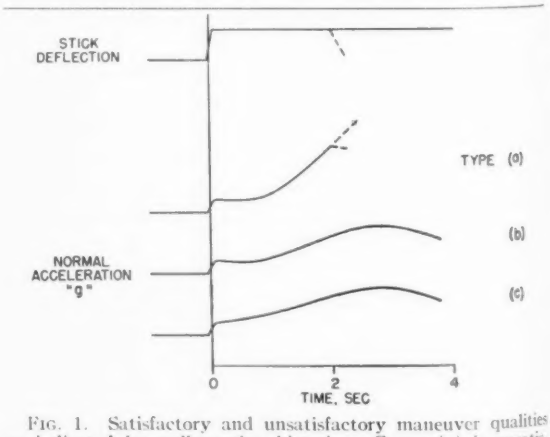

Fig. 1. Satisfactory and unsatisfactory maneuver qualities as indicated by pull-up time-histories. Curve (a) is unsatisfactory; curve (b) meets the divergence requirement; curve (c) meets both the divergence and anticipation requirements.

can readily notice the difference. Details of changes in curvature of other portions of such records, so small as not to be immediately observed in the time-histories, have also been found to be evident to pilots.

Pilots' opinions of the flight characteristics as observed in normal flying were found to correlate with their opinions of these pull-ups. Tentative wording of specific maneuver requirements, based on these three types of pull-ups, was given and discussed in reference 2. Briefly, the "divergence requirement" is that the normal-acceleration time-history shall become concave downward within 2 sec., and the "anticipation requirement" is that the slope of the normal-acceleration curve must remain positive from the start of the maneuver until the maximum acceleration is approached. A supplementary requirement, chosen for greater ease of measurement, is that within 10 sec. after a small disturbance, and also within 10 sec. after initial return to 1g, the change in normal acceleration shall not exceed $\frac{1}{4}g$. This supplementary requirement primarily tends to ensure that an oscillation rather than a sudden divergence will occur; thus it supplements the "divergence requirement" but provides no information relative to the "anticipation requirement."

Before discussing means to achieve these desired characteristics, it should be pointed out that the requirements stated, particularly the divergence requirement, call for minimum rather than optimum qualities. It should also be pointed out that these are necessary but not sufficient conditions. Other characteristics needed for satisfactory longitudinal flying qualities have been found to include: avoidance of excessive control friction; avoidance of certain types of transient control forces; and provision of centering tendencies and means for trimming stick forces to zero. These items are discussed in reference 1.

Methods for Achieving Desired Maneuver Characteristics

Among the numerous methods that either are in use or have been suggested for improving helicopter stability and control characteristics and which might seem applicable to these problems are the following: (1) horizontal stabilizers for adding stability with angle of attack; (2) stable fuselage shape; (3) use of increased tip speeds to reduce the tip-speed ratios; (4) increased damping in pitch by means of various special devices; (5) forward position of helicopter center of gravity in conjunction with offset hinges, tandem rotors, or rigid rotors; (6) variation of blade pitch with normal acceleration or coning angle; (7) stick-force devices providing stick-free stability (that is, the control stick moves in the pilot's hand and applies corrections for him); and (8) use of an autopilot or autopilot components to move the rotor controls without moving the control stick held by the pilot.

Examination of each of these items indicates that it is not a cure-all, equally appropriate for all types and sizes of helicopters and without penalties or limitations of any kind. Consider the idea of using a stable fuselage shape, for example. Although a streamlined fuselage may be less unstable than one with a nose resembling a shovel, a truly streamline body with no drag losses due to flow separation and having a reasonable shape and c.g. location inherently tends to be unstable. Thus, although careful design will reduce the instability, a stable fuselage shape will be obtained only at the expense of aerodynamic or structural efficiency. This means, incidentally, that, whenever an efficient fuselage shape is used, the problem of overcoming fuselage instability must be added to that of overcoming rotor instability, increasing the need for stabilizing devices.

The use of lower tip-speed ratios to reduce instability involves a compromise with performance losses; the extent of this compromise can be estimated from references 3 and 4.

If carried to an extreme, the use of forward c.g. location in conjunction with offset hinges, tandem rotors, or rigid rotors could result in larger blade flapping and dragging angles than would be desired or in an increase in blade bending moments.

The use of variation of blade pitch with coning angle to provide stability with angle of attack was discussed in reference 5. Examination of this arrangement by means of the theory of reference 3 indicates that improvements in maneuver stability should be obtainable with present helicopters but that, for a relatively high-speed helicopter for a maneuver at a given normal-acceleration value, an increase in instability would result. For present helicopters, the amount of "pitch-cone" change which can be used would be expected to be limited by practical problems such as the need for adequate rotor r.p.m. governing at all power conditions.

The use of stick-force devices to provide stick-free stability is, by definition, not applicable to the stick-fixed divergence requirement given. This requirement, however, was a minimum one and does not rule out the possibility of long-period longitudinal oscillations of slowly expanding amplitude. Therefore, insofar as long-period motions are concerned, the requirement limits the amount of instability rather than requiring positive stick-fixed stability. To obtain the further advantages of designing for indefinite hands-off flight and at the same time to obtain suitable stick force gradients, there are several alternative possibilities. One is to increase further the stick-fixed stability until motions of the helicopter following a disturbance are damped out and to employ simple trimmable centering devices such as springs for centering action and suitable feel; another is to provide stick-free stability by means of a special device and to ignore the long-period motions that will occur stick-fixed. Special devices that have been given study and development include airfoils attached to the controls and rotor-blade attachment configurations. The extent to which stick-free stability can satisfactorily mask moderate amounts of stick-fixed instability has not been determined, but it may prove to be the most expedient course in some applications—as, for example, in handling the instability present in

the transition region between hovering and forward flight. One primary limitation, however, is that any control friction present, as well as any tendency of the pilot to restrain the stick, reduces the effectiveness of such devices. Another limitation is that, if too large an amount of stick-fixed instability is masked (that is, if the stick-fixed maneuver requirements are not met), the stick may reach the forward stop during recovery from an intentional maneuver, at which point the stick-free characteristics are nullified and a dangerous condition could result.

The use of autopilots or autopilot components for stabilization will have important applications. It would appear, however, that considerations of weight and cost would tend to discourage its full use, at least on small and inexpensive helicopters. Also, the flight characteristics must be reasonable in event of failure of such devices. The helicopter should at least meet the divergence requirements given, with the autopilot units inoperative.

There are also limitations and design compromises involved in the use of horizontal tail surfaces or added damping as obtained by special devices, and these also fit the idea that a well-balanced design rather than use of any single method will, in general, be the best design practice. Because these two methods have been demonstrated to be effective, however, and because the greatest experience has been gained with them, they will be discussed in a relatively complete manner.

Horizontal Stabilizers

In order to determine a dividing line between satisfactory and unsatisfactory longitudinal characteristics, a means of varying these qualities was needed. A horizontal stabilizer was added to a single-rotor helicopter for this purpose, and what was thereby learned about the horizontal tail as a means for improving maneuver qualities will now be discussed.

Effect of Fixed Tail on Maneuver Qualities

The effect of a fixed tail surface (to be described later) on the pull-up characteristics at cruising speed is shown in Fig. 2. The addition of the tail removed the divergent tendency; the improvement corresponds to changing from type (a) to type (b) of Fig. 1. As explained in reference 2, this change can be ascribed almost entirely to the change in angle-of-attack stability and thus indicates the basic effect of such a change regardless of whether a tail surface or some other method is employed to obtain it. Flight measurements showed that the angle-of-attack stability of the helicopter had been changed from unstable to stable; a difference in stick displacement per g of about 6 in. is represented.

The time-history for the tail-on case, as shown in Fig. 2, is not a completely satisfactory one because of the pause in development of normal acceleration at the start of the maneuver. The source of this pause is the immediate increase in thrust obtained from the rotor when control is applied; this increase tends to die out

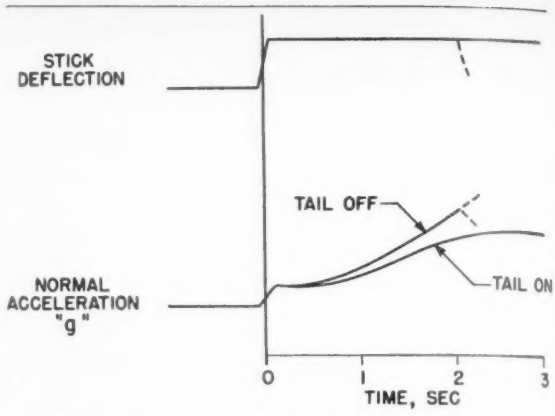

Fig. 2. Effect of fixed tail on pull-up characteristics.

quickly, while that due to the progressively increasing pitching velocity (and, hence, angle of attack) of the helicopter builds up. Some evidence of the importance of preventing this pause was obtained by comparison of the results obtained on two different helicopters, but it was desired to confirm these results by making a similar change in the characteristics of a helicopter in which the pause had been recognized as objectionable.

Effect of Movable Tail on Maneuver Qualities

To achieve such a change in characteristics, it was decided to link the tail surface already used to the longitudinal controls. In this way a part of the pitching moments needed for a pull-up could be obtained from the tail surface, just as moments are obtained from the elevator control on an airplane. It follows that, for a given final or maximum acceleration value (or, in other words, for a given maneuver), less deflection of the rotor controls is required. In turn, since the initial jump in the normal-acceleration time-history resulted from the rotor control displacement, it should also be reduced in relation to the rest of the time-history, thus reducing, if not eliminating, the pause in development of acceleration.

To reduce the angular throw required for the tail, its effectiveness was increased by an increase in span. A series of angle ranges was tried, providing successive increases in the ratio of stabilizer movement to rotor-control movement. An improvement was noted for moderate ratios, and, since no disadvantages were apparent, the ratio was further increased until the pilots were definitely satisfied with the early portion of the maneuver.

The effectiveness of the linked tail in reshaping the early part of the time-history is shown by Fig. 3. For this test the tail was linked so as to move about 4° for every degree of rotor cyclic-pitch control; this was the maximum ratio used. Results were available for several initial tail angles, and the case shown was chosen because the shape of the latter portions of the curve was almost identical to that for the fixed-tail case. The vertical scales for Fig. 3 were so chosen as to make the maximum values coincide; actually, a given stick dis-

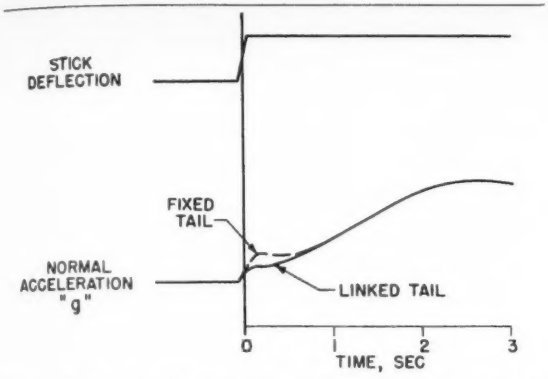

FIG. 3. Effect on pull-up characteristics of linking tail to longitudinal controls.

placement would cause a larger acceleration with the linked tail. (The pilots soon became accustomed to the increase in sensitivity and did not object to it.)

It will be seen that, as expected, the relative proportions of the initial jump and pause are reduced and that a far more continuous increase in normal acceleration is obtained.

These trials confirmed the need for minimizing the pause in the early development of normal acceleration in a pull-up, although it was found that the pause did not have to be completely eliminated rather than minimized to the point where it is difficult to detect by measurement. (When the pause is only 0.1 or 0.2 sec. long, it tends to be lost in the once-per-blade vibration present on the actual records.) These trials also showed that, by using a horizontal tail linked to the cyclic control, both of the objectionable features of the unsatisfactory pull-up time-history can be removed and satisfactory maneuver characteristics can be obtained.

The use of the linked tail reduced the design compromises involved and permitted use of a more effective tail. With this tail, the motion of the helicopter following a disturbance in pitch at cruising speed was virtually deadbeat, whereas with the smaller fixed tail a slowly damped oscillation resulted. The helicopter could apparently be flown indefinitely with the longitudinal control held fixed, in either calm or rough air, although actual trials were limited to a few minutes. When all of the controls were fixed for long periods, however, a complex oscillation involving lateral and directional motions resulted which, while showing no tendency to exceed a particular amplitude, was not comfortable and would be corrected for by occasional control motions in all normal flying.

Nose-up tail angles for full-forward control of from 5° to 14° were used in the course of various tests. The pilots found the 5° setting to give desirable added stability as compared to the 14° setting, but they classified both as satisfactory.

Problems of Design of Tail Surfaces

With regard to the problems involved in tail-surface design, a primary problem lies in the variation of airflow angle at the tail location with power setting and forward speed. Before installing the test tail surfaces, a flow-angle survey was made at the intended tail location. The results are shown in Fig. 4 and serve to illustrate the compromise involved in choosing an angle setting for a fixed tail. At the higher forward speeds, where the tail moments are of greatest concern, it will be noted that for a given trim condition the flow angle does not change rapidly with speed. On the other hand, the full-throttle curve shows about 20° more downward flow angle than the autorotation curve. The helicopter, unlike the airplane, glides and climbs with the fuselage at about the same attitude angle, so that a change in flight-path angle causes a similar change in the flow angle.

The theoretical curves of Fig. 4 show this same trend with power change, and the absolute values are in reasonable agreement at the higher speeds. The disagreement at the lower speeds is taken to mean that use of a more refined downwash treatment would be necessary if any real accuracy were desired at these speeds. (Downwash was taken simply as the mean value at the rotor—that is, $C_L/4$ rad.)

The fixed tail assembly used is shown in the headpiece on page 27. On the basis of the flow-angle survey of Fig. 4, it was initially set at 0° incidence as a precaution against possible excessive nose-down moments in autorotation. To prevent stalling the tail when operating at high power settings, the fact that low aspect ratios result in higher stall angles was made use of. A gap was left between the surfaces and the fuselage, otherwise the short surfaces would still have had a high effective aspect ratio and a low stalling angle.

A biplane arrangement was adopted to reduce the vertical forces on the tail assembly during hovering and vertical climb and descent.

The fore-and-aft location chosen was about five-eighths of the rotor radius aft of the rotor center. This position was chosen, on the basis of unpublished data obtained on the Langley helicopter test tower, to ensure that the edge of the rotor slipstream would not move across the tail unless rearward speeds greater than about 15 or 20 m.p.h. were reached when clear of ground effect. When flying close to the ground, a somewhat greater speed should apply. It is believed that when abrupt undesired changes in pitching moments are reported to result from the use of tail surfaces, the cause often is that the tail has been located near the edge of the rotor slipstream instead of using a location such that

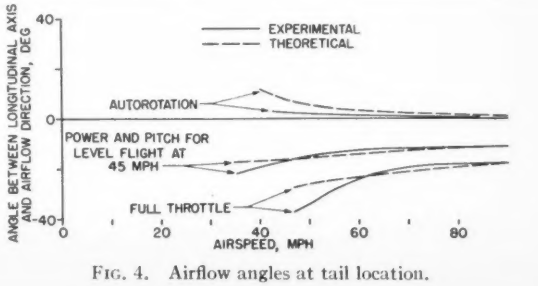

FIG. 4. Airflow angles at tail location.

the tail is either always inside or always outside of the slipstream.

To determine whether the tail surfaces caused any observable adverse effects on flying qualities, two N.A.C.A. test pilots tried various specific maneuvers, in addition to the pull-ups described, with and without the original fixed tail. Landings, take-offs, turning over a spot in moderate winds, vertical descent, and rapid power changes at various forward speeds were included. No adverse effects on flying qualities could be found. It seems inevitable, however, that, if a tail surface should be used as the sole means for offsetting rotor instabilities many times greater than those present here, its size would be sufficient to cause adverse effects in some of these maneuvers.

Although no adverse effects on ease of handling could be found, this fixed tail surface did, however, limit the attainable level-flight top speed of the helicopter, the download on the tail causing the stick position for trim to reach the forward stop prematurely. To remove this effect would have required a nose-up setting of about 15°. Since the download had contributed materially to the stability (by reason of keeping the aircraft center of gravity ahead of its aerodynamic center), a sizable increase in tail area would then have been required to restore the original stability. It was felt that this combination of changes with the fixed tail would cause an excessive nose-down moment on the aircraft upon entering autorotation. With the movable tail, little concern was felt about nose-down moments upon entering autorotation because rearward motion of the stick could readily change the tail angle to zero or even to a large nose-down angle if necessary. Also, the movable tail was considered less likely to be stalled during maneuvers. It was on this basis that the span of the tail surfaces was increased by adding cuffs on their inner ends, increasing the aspect ratio and, hence, the lift-curve slope, as well as the area.

For practical use it would be desirable to link the tail to the "mixing linkage" usually found near the rotor head and thus change its angle with change in collective pitch, as well as with change in cyclic pitch. The resulting variation of tail angle with flight condition could then be made to vary in the desired direction with power condition, as well as with forward speed.

Increased Rotor Damping

In order to provide a check on the generality of the tentative requirements, it was considered desirable to vary the characteristics of a different helicopter and to use different means for obtaining the variation. A helicopter of smaller size became available which, as standard equipment, had a stabilizing device that added rotor damping in roll and pitch. (The damping referred to is the rolling or pitching moment applied to the helicopter as a result of a rolling or pitching angular velocity of the helicopter.) Although for practical reasons the recommended settings of this device fix the damping within narrow limits, it was feasible for test purposes to use it to vary the damping over a two-to-one range.

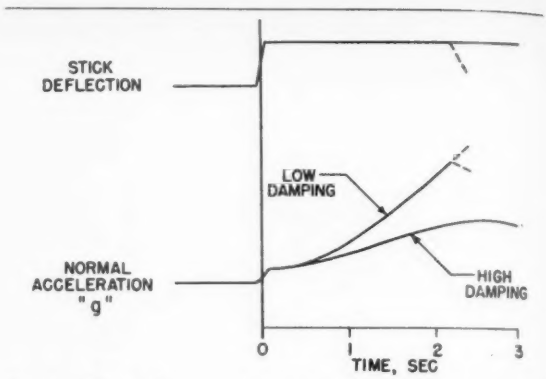

Fig. 5. Effect of increased damping in pitch on pull-up characteristics.

Numerous specific devices or methods exist for increase in rotor damping. Among them are the use of the gyroscopic action of a rotating bar that is tied into the control system; the increase in damping of the main rotor by use of a control rotor that has heavy blades and, hence, high damping; servocontrol surfaces attached to torsionally flexible blades; autopilot components; offset flapping hinges; and increased blade inertia as a result of heavier construction or the adoption of tip-jet power units. Because an existing device was used, little experience was gained with the problems of design of such devices, and the discussion to be given will be confined largely to the basic effects of increased rotor damping.

Effect of Rotor Damping on Maneuver Qualities

The effect of the two-to-one variation in damping on the maneuver qualities at cruising speed is indicated by the pull-up time-histories of Fig. 5. The low-damping case was considered unsatisfactory by the pilots. The normal acceleration curve did not become concave downward within the specified 2 sec., and, because of the impression that continued divergence would occur, corrective control was generally applied at the end of about 2 sec. The high-damping case was considered satisfactory, and the normal acceleration curve did become concave downward within 2 sec. Intermediate damping values gave intermediate results.

It may be wondered whether rotor damping affects the previously-discussed pause in acceleration at the start of the pull-up maneuver. The pilots did not notice any objectionable pause for any of the damping values used, nor were there any flat spots in any of the pull-up records which lasted more than about 0.1 or 0.2 sec. The relatively low moment of inertia in pitch of this helicopter is believed to be a major reason for this favorable result. There was no indication that increased damping could be used to eliminate or mask a pause in acceleration in cases where this characteristic is initially objectionable.

The effect of changes in rotor damping on the motion of the helicopter following a disturbance was also in-

vestigated. The supplementary requirement (limiting the acceleration developed soon after a disturbance) was again found to separate the satisfactory conditions from the unsatisfactory ones. Progressive increases in rotor damping resulted in progressive increases in the damping of the long-period longitudinal oscillations. With the helicopter on which the damping was varied, however, deadbeat characteristics were never completely reached, even with the largest damping used. On the other hand, previous tests of a supposedly identical helicopter in an "as-received" condition did show substantially deadbeat characteristics, and this helicopter could be flown with stick fixed for relatively long periods in mildly rough air. It is possible that detailed differences in fuselage shape and, hence, in pitching moments caused this discrepancy; in any event, the results did demonstrate that increased damping is an aid in approaching deadbeat characteristics.

The discrepancy obtained for the two apparently identical ships serves to suggest that a check of maneuver stability might well become a part of the initial test flying of all production helicopters so that individual subnormal characteristics could be remedied.

Effect of Rotor Damping on Other Characteristics

The effect of the increase in damping on other handling qualities characteristics was briefly investigated. The available rates of roll were decreased in proportion to the increased damping achieved. This effect was noticeable to the pilots and tended, with the largest values of damping used, to give the initial impression of inadequate control. Careful consideration of the flight conditions covered, however, including landings in moderately gusty air, did not reveal any conditions where the control was actually inadequate. On the other hand, if still larger amounts of damping were used or if flights were made under more exacting conditions, it would be expected that means would have to be employed to offset some portion of this reduction in rate of roll.

In addition to the specific results given for longitudinal forward-flight maneuver qualities, there are numerous indications that added rotor damping tends, in general, to improve other helicopter flying qualities. For example, the desirability of reducing the control sensitivity of small helicopters by means of added damping was pointed out in reference 1, and the special need for added damping in roll in high-performance helicopters was explained in reference 6. The limiting value of damping for overall improvement seems generally to be set by incidental effects of the method used. For example, large amounts of damping as obtained by one particular device were found to be accompanied by undesirably large pitching motions following application of rolling control. With another device, at the higher forward speeds which are now becoming of interest, added vibration problems and added instability with angle of attack appear to be inherent. As a final example, an increase in blade weight tends to increase damping, but structural penalties would be expected to restrict this approach in many cases; also, as may be learned from study of reference 6, added blade weight cannot be used as the sole means of avoiding unstable damping in high-performance helicopters.

Concluding Remarks

The results presented show that it was possible, by two widely different methods, to exceed greatly the minimum requirements for forward-flight maneuver qualities. It was also indicated that numerous other methods exist which, if used in moderation, will contribute to improved maneuver characteristics without causing serious design compromises. For the purposes of some agencies, written requirements for maneuver qualities should doubtless still be lenient and should still lean toward allowing many alternate methods of improvement. It is felt, however, that enough is now known to permit the incorporation of some specific requirement for maneuver qualities in all formal helicopter specifications or requirements.

It is also concluded that the best design practice will be, in general, to use several methods, such as those discussed, in combination with one another rather than to rely solely on one method.

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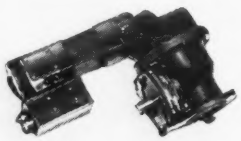
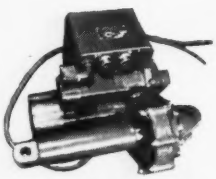
EEMCo technical bulletin

MOTOR ACTUATORS FOR AUTOMATIC FLIGHT

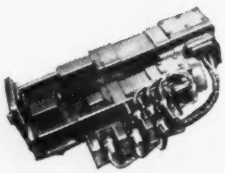
Today's aircraft fly on the edge of human capabilities and endurance. A transition from conventional piloted aircraft to pilotless types is taking place. The development of foolproof power units to actuate controls is a primary factor in the achievement of automatic flight. These units are being designed and produced by EEMCO in close cooperation with the builders of tomorrow's aircraft.



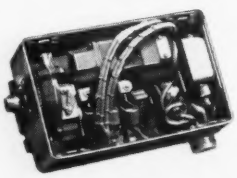
Rotary Actuator for Rugged Duty This Rotary Actuator was designed for trim tab actuation in a long range bomber involving the most rugged duty cycle. It operates almost continuously with the automatic pilot. Required duty cycle is one second full load, one second off and one second full load in opposite direction, continuous. Silicone insulated and high temperature materials used throughout.



Stabilizer Actuator for Large Jet Fighters This unit incorporates two motors of different size, driving into individual gear reductions to operate the screw jack. Small motor of 1/10 h. p. output operates almost continuously with automatic pilot. The large intermittent duty 3.3 h. p. motor provides manual operation of screw jack by pilot for maneuvering.



Double Motor Power Unit This unconventional system operates the horizontal stabilizer on a turbo prop aircraft of recent design. A small continuous duty motor of 1/15th h. p. operates through a gear reduction in conjunction with automatic pilot. Large intermittent duty 3½ h. p. motor with direct drive of 12,000 rpm is used for manual operation.



Rotary Actuator Package This system provides manual or automatic pilot elevator operation on one of the latest jet fighters. Totally enclosed in box equipped with mounting bracket it incorporates motor, magnetic clutch, radio noise filter and brake. Gear reduction, and auxiliary gear reduction operate adjustable travel limit switches and position indicator. Output rpm at 3 inch – pounds loads, 2500. Weight, complete, 3¼ pounds.

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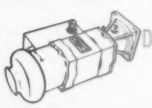

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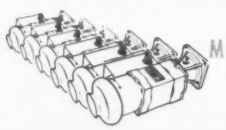

MANUFACTURING

4

I.A.S. Previews

Summaries of Current Papers Accepted for I.A.S. Publications

Nonsteady Supersonic Flow About Pointed Bodies of Revolution

By

William H. Dorrance

University of Michigan, Willow Run Research Center

The general velocity potential for a slender pointed body of revolution oscillating periodically in a supersonic uniform stream is presented. The solution is shown to reduce in the limit to the sum of the well-known stationary source-sink and doublet solutions when the frequency of oscillation approaches zero. Stability derivatives for low-frequency oscillations are determined by using the potential expression obtained by expanding the oscillating velocity potential in powers of reduced frequency, retaining only the first-order terms in reduced frequency.

In particular, the following four cases of steady and nonsteady supersonic motion are treated: (1) harmonic pitching about a point x_0, (2) harmonic normal oscillations in pitch, (3) steady pitching about a point x_0, and (4) steady angle of attack.

Equations for the slender-body theory normal force and pitching moment stability derivatives are also determined.

Two types of bodies of revolution are examined to demonstrate how the aerodynamic stability derivatives may be varied by changing the contour of the body. "Flaring" the aft end of the body is shown to increase the lift as well as the aerodynamic damping moment of a finless body.

Simplified Design Comparisons of Axial Compressors

By

Frank L. Wattendorf

Air Engineering Development Division, U.S.A.F.

This paper reports a continuation of studies initiated in 1944 regarding potential improvements of turbojet propulsion systems for supersonic flight as suggested originally by Dr. Theodore von Kármán, Chairman of the U.S.A.F. Scientific Advisory Board and Chief Scientific Adviser to the Air Engineering Development Division.

Simplified design comparisons of axial compressors, with particular emphasis on the attainment of a high rate of mass flow per unit frontal area, are discussed. This feature is important, not only in the application of turbojets to the propulsion of supersonic aircraft, but also in the study of future potential requirements for jet-engine component testing and for application to the design of more compact compressor systems for wind tunnels such as those at the Arnold Engineering Development Center.

A comparison is made of some aspects of axial compressor design for accommodating a high rate of mass flow. In particular, the influence of hub ratio and axial Mach Number on the stage pressure ratio based on assumed limitations of all relative and absolute Mach Numbers is given for compressor types designed according to various principles such as free vortex flow, rigid body prerotation, and arbitrary distribution of rotor work.

The important relationship between maximum temperature rise and mass flow ratio is derived for several compressor types so that a general qualitative picture is given of the influence of compressor type on the relationship between temperature rise and mass flow ratio. This study represents a qualitative method of comparing compressor types and refers to the inlet stage alone, which is usually critical for mass flow.

The Effect of Changes in Altitude on the Controlled Behavior of a Gas-Turbine Engine

By

Seymour C. Himmel and Richard P. Krebs

Lewis Flight Propulsion Laboratory, N.A.C.A.

For the various phases of flight operation of an aircraft powered by a gas-turbine engine, a considerable range of power output is required of the engine. Not only are different power levels required, but changes from one power level to another must be accomplished in a short period of time. It is the function of the control to conduct the engine quickly and safely from one operating level to another without encountering excessive values of speed, torque, and temperature. The design of a control system for a gas-turbine engine is further complicated by the fact that the reaction of the engine to a given change in one of the independent variables changes with the initial control setting and with altitude. As a result, the control is expected to regulate what amounts to a variety of power plants.

This paper presents a theory of the change in engine response with altitude which has been derived independently by several analysts, together with some experimental data corroborating these analyses. The data show that the response of the engine at any altitude may be computed from measurements made at sea level.

The sea-level and altitude transient behavior of an engine operating under a proposed control is studied with the aid of an electronic analog computer to illustrate the effect of the changes in engine dynamics with altitude. From these studies, it appears necessary to use compensation to vary the gain and time variant parameters of the control loops with altitude if satisfactory performance is to be obtained.

Preprint No. 320

Please do not order Preprints of these papers at this time.
See page 132 for Preprints that are immediately available.

A Limiting Case for Missile Rolling Moments

By

Ernest W. Graham

Douglas Aircraft Company, Inc.

Missile rolling moments are studied by linearized theory for the limiting case in which infinitely many wings are symmet-

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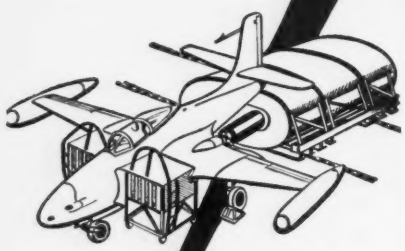

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trically arranged around a circular cylinder.

This case is physically interesting when interference effects prevent the rolling moments from getting too far out of the range of those practically obtainable with a finite number of wings. Mathematically the limiting case is convenient because it can be analyzed through knowledge of the rate at which angular momentum is being added to the air, the rolling moment being proportional to this quantity.

The analysis is independent of Mach Number, and, since there are few restrictions on the geometry of the system, it should furnish an upper limit for rolling moments for a variety of configurations and flight speeds. Many cases with a finite number of wings are difficult to analyze, and knowledge of a limiting value may help in checking intermediate cases.

For a delta wing system with leading edges on the Mach lines, body of zero radius, and each wing acting as an aileron, the rolling moment coefficient for an infinite number of wings is π times that for the planar wing and 1.85 times that for the cruciform wing. For *narrow* delta systems the above values apply exactly for the planar case and approximately for the cruciform.

Wing-tail interference effects on aileron rolling moments may also be studied for the limiting case. Here, all angular momentum is removed from the disc covered by the tail (unless opposite surfaces of the tail are designed to "float" relative to each other and are controlled only through the sum of their displacements). If the tail disc is as large as the wing disc, then no resultant rolling moment is produced by wing ailerons in the limiting case. This assumes the discs to be concentric. For a lifting wing, the effective displacement of the disc centers might introduce important nonlinear effects.

Damping in roll can be studied by assuming the wing angle of attack proportional to the radius. Equating the damping moment to the aileron moment gives an equilibrium rate of roll which may be expressed as the ratio of tip helix angle to aileron displacement angle.

For the delta wing system previously considered (with sonic leading edges), this ratio decreases as the number of wings increases. For an infinite number of wings, the ratio is two-thirds of the planar value or 0.73 times the cruciform value. For a given aileron displacement, the equilibrium rate of roll is therefore *decreased* by increasing the number of wings. Physically this corresponds to the fact that interference effects on damping in roll are less than on aileron rolling moments. The above figures are *approximately* correct for *narrow* delta systems.

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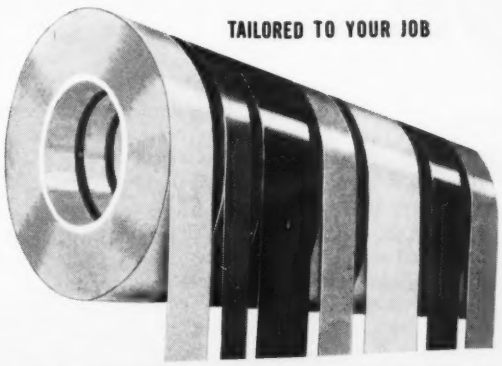

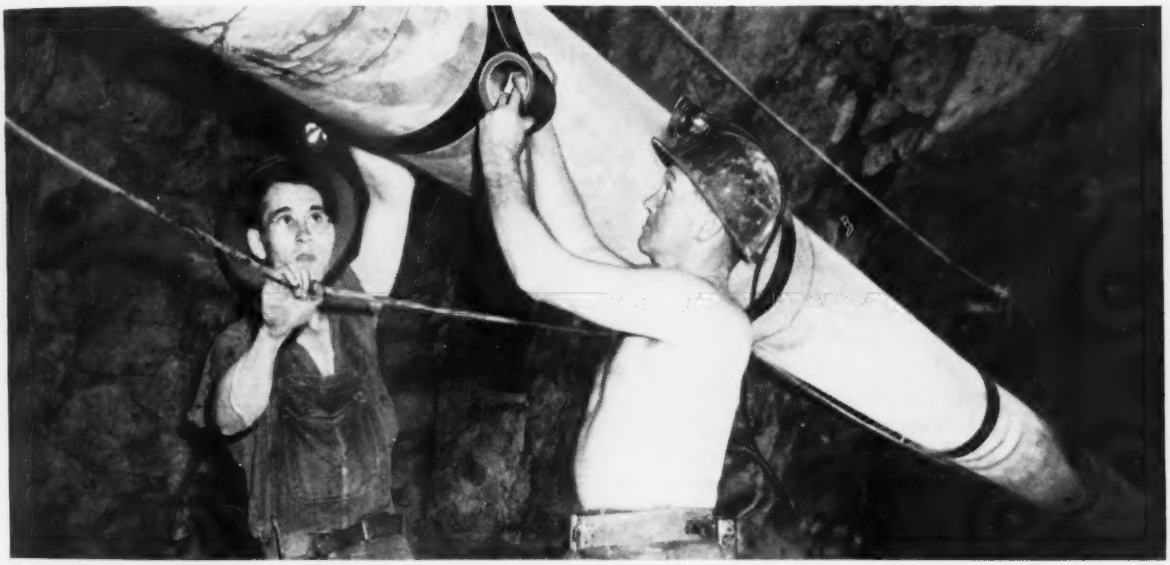

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I.A.S. News

(*Continued from page 6*)

This invaluable I.A.S. publication, like Caesar's Gaul, is divided into three parts: Catalog Section; Products Directory; and Index to Principal Manufacturers and Sources of Supply.

The Catalog Section contains a file of individual company catalogs from 55 leading manufacturers of products, parts, and materials used in the construction and equipment of aircraft. The technical information found on these pages is greater than in any of the previous issues.

In the Products Directory is located a register of approximately 30,000 individual listings, inventoried alphabetically. This constitutes a general overall guide to the manufacturers of more than 2,200 aircraft parts, materials, accessories, and equipment.

The third and final portion of the Seventh Annual Edition of the CATALOG indexes the names and latest addresses of the principal manufacturers and primary sources of aircraft components.

A.S.M.E. Holds Aeronautical Meeting

The Semi-Annual Meeting of the Aviation Division of the American Society of Mechanical Engineers is scheduled to take place on June 13 at the Royal York Hotel, Toronto, Canada. The program will be cosponsored by the Institute of the Aeronautical Sciences, Society of Automotive Engineers, and A.S.M.E.'s Gas Turbine Power Division.

Five papers on the design and operational problems of turbine-driven commercial aircraft (jet and turboprop) will be presented during the two technical sessions. Three of the five authors will come from England to deliver their papers; the other two will represent the Canadian aircraft and air-line industry.

I. M. Hamer, M.I.A.S., Chief Engineer, Dowty Equipment of Canada, Ltd., as Chiarman, and R. E. Small, T.M.I.A.S., Application Engineer, Aircraft Gas Turbine Division, General Electric Company, as Vice-Chairman, will conduct the morning session at which three papers will be presented. During the afternoon session, H. S. Rees, M.I.A.S., Chief Aeronautical Engineer, Department of Transport Air Services, Civil Aviation Division, Canadian Government, will be the Chairman, with H. Hollerith, Materials Engineer, The Glenn L. Martin Company, acting as Vice-Chairman.

An inspection trip to A. V. Roe Canada Ltd. is scheduled for June 14.

Necrology

Wallace J. Christian

Wallace John Christian, T.M.I.A.S., was killed on January 10, 1951, in an airplane crash at Muroc, Calif., while working as Flight Test Engineer for Ryan Aeronautical Company.

Born on May 9, 1921, at Beaver, Utah, Mr. Christian attended the University of Southern California from October, 1946, to June, 1950. He received his Bachelor of Engineering degree with an aeronautical engineering major from U.S.C. about 1 year ago. The following month, July, he went to work for Ryan as a Flight Test Analyst on aircraft and aircraft parts.

In addition to his membership in the I.A.S., he also belonged to Tau Beta Pi and Alpha Eta Rho.

William V. Hanley

William Vincent Hanley, M.I.A.S. disappeared on November 18, 1950, while flying his personal plane into Northern California where he and three friends had planned a hunting trip. An extensive ground and aerial search for the lost plane and its four occupants failed to disclose any evidence as to their fate.

At the time of his disappearance, Bill Hanley was Assistant Manager of Standard Oil Company of California's Aviation Division. He began his professional career with this same firm in 1933 in their Research and Development Department. In 1936, he was made Research Engineer and was placed in charge of the Motor Fuel Engine Research Laboratory. During World War II, he became associated with the Intercontinental Division of T.W.A. as an Engineering Pilot. Here, his work included considerable cooperative flight testing of an engineering nature for T.W.A. and other air lines, as well as the Army, Navy, and aircraft-engine manufacturers. He was a member of sundry national committees of the Cooperative Research Council's Aviation Fuel Division.

Born in Salt Lake City on October 30, 1909, Mr. Hanley attended Oregon State College, the University of Kansas, and the University of California. He received his B.S. degree in Mechanical Engineering in 1933 and his M.E. degree in 1938. He was the holder of the C.A.A. Certificate No. 66033 with single- and multiengined land ratings. Among the other various technical and professional societies of which he was a member were the S.A.E. and the Society of American Military Engineers. He is survived by his widow.

Fred W. Herman

Fred Weld Herman, M.I.A.S., died on March 26 at the Seaside Hospital in Long Beach, Calif., after a brief illness.

Born in Beloit, Kan., on April 7, 1892, Mr. Herman attended the University of California, which he left to join the U.S. Army in World War I. After serving as a pilot in the Aviation Section of the Signal Corps, he returned to his interrupted studies at the University of California and was graduated from there in 1921 with a B.S. degree in Mechanical Engineering.

For the next 8 years, Mr. Herman was associated with the U.S. Army Air Corps' Materiel Division, Dayton, Ohio, in the civilian capacity of Aeronautical Engineer. His activities there included working out the flight-test program for the first round-the-world flight of the four Douglas "World Cruiser" hydroplanes in 1924. These four ships took off from Santa Monica on March 17 and landed at Seattle 175 days later, on September 28, after covering a distance of 26,345 miles. Mr. Herman was also responsible for all engineering on what was to be the first successful nonstop flight across the Pacific. This particular flight was made on June 28–29 from Oakland, Calif., to Honolulu, T.H., in an Army trimotored Fokker.

Mr. Herman joined the staff of Douglas Aircraft Company, Inc., in 1930 as Project Engineer on the original DC-1 and the first DC-2's. He was later promoted to Assistant Chief Engineer and in 1939 was advanced to Chief Engineer for the Santa Monica Division. At the time of his death, he was General Manager of Douglas' Long Beach Plant.

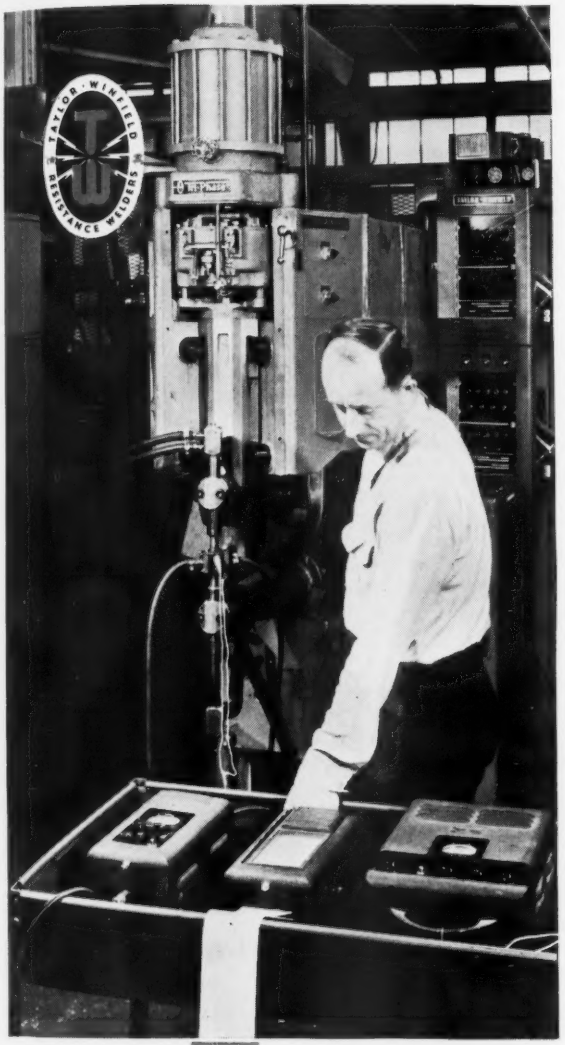
Mr. Herman is survived by his widow, the former Edith Brooks, and a daughter, Mrs. Joan Lombard.

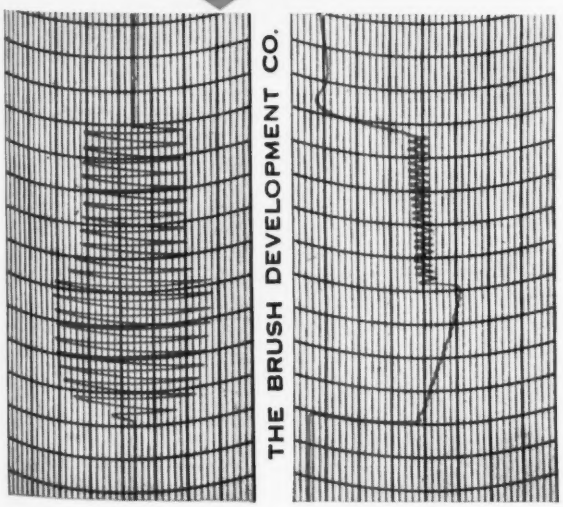
Preston Lockwood

Preston Lockwood, A.M.I.A.S., President of Brewster Aeronautical Corporation, died at his New York City home on March 30 after an illness of 3 months. He was 59 years old.

A native of St. Louis and a 1912 graduate of Washington University, Mr. Lockwood attended Oxford University, England, from 1913 to 1917 as a Rhodes Scholar. During part of his

(*Continued on page 40*)





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Necrology

(*Continued from page 38*)

time at Oxford (1915–1916), he was active with the American Field Service. He enlisted in the French Army in 1917 and toward the latter part of that year transferred to the American Expeditionary Forces as a First Lieutenant in the U.S. Army's Field Artillery.

In 1919, Mr. Lockwood entered Columbia Law School, from which he was graduated in 1922 with an LL.B. degree. He was admitted to the New York State Bar in 1924 and, from then until 1942, was a partner in several law firms, including Davisson, McCarty & Lockwood.

Mr. Lockwood was a Director of Consolidated Aircraft Corporation from 1929 to 1941. He first became associated with Brewster in 1942 as Secretary and Assistant General Counsel. In 1942, he was made a Director of that firm and in 1943 was elected to its Presidency.

William G. Ovens

William George Ovens, A.F.I.A.S., passed away suddenly last November 27 at the age of 43.

Mr. Ovens was born on August 8, 1907, at Wallkill, N.Y., and was a student at the Union Endicott (N.Y.) High School. From 1926 to 1928, he pursued a course of Mechanical Engineering at Lehigh University.

Except for approximately 6 months as Draftsman with The Fairbanks Company, Mr. Ovens had been with Wright Aeronautical Corporation during most of his professional career. He was originally employed by Wright in February, 1929, in the capacity of Draftsman. In the interim, he was promoted through the grades of Checker, Test Engineer, Assistant Project Engineer, Project Engineer, Special Project Engineer (Two-Row Aircraft-Engine Development), Staff Engineer, and Gas Turbines Assistant Engineering Manager. At the time of his death, he was Engineering Manager of the Production Models Division.

Mr. Ovens was responsible for the design and development of the Wright Cyclone 14 R-2600. The success of this engine in transatlantic and transpacific operations during World War II and later is a testimony as to his outstanding technical ability.

In addition to his membership in the I.A.S., Mr. Ovens was a member of the Society of Automotive Engineers. He is survived by his wife and two children.

F. W. Pawlowski

Felix W. Pawlowski, Professor Emeritus of Aeronautical Engineering at the University of Michigan, died in Pau, France, on February 17, 1951. He had made his home in France shortly after his retirement in 1946 from the Michigan faculty.

Born near Warsaw, Poland, on July 23, 1876, Professor Pawlowski received his Mechanical and Electrical Engineering degrees in 1896 from the Engineering College, Mittweida, Saxony. From then until 1908, he was engaged in various machine industries of Europe as Designer, Assistant Chief Engineer, and Chief Engineer. He then left commercial employment to take postgraduate work at the Brunswick, Germany, Engineering College.

In that same year, 1908, Professor Pawlowski witnessed some of the early exhibition flights of the Wright Brothers from Le Mans Field, France. From this stemmed his interest in Professional aeronautics. As soon as the University of Paris, France, had established the world's first chair of aeronautics in 1909, Felix Pawlowski enrolled for further postgraduate study, and in 1910 he was given the University of Paris' Certificate d'Étude (Aeronautics). Four years later, the University of Michigan granted him a Master of Science degree.

After receiving his Paris degree, he came to the United States, and from 1911 to 1913 he was employed by American concerns in the capacity of Motor-Car Designer. On February 15, 1915, 2 years after he had joined the University of Michigan faculty, he began to develop one of the first regular courses in the United States to provide credit toward an aeronautical engineering degree. By 1922, he held the rank of full professor and 8 years later was named the Guggenheim Professor of Aeronautical Engineering.

Professor Pawlowski authored numerous articles and papers that were printed in American and European scientific publications. He also reported the results of many investigations and research projects.

In addition to being a Founder Member and Fellow of the Institute of the Aeronautical Sciences, he was a member of many American and foreign technical societies. Among them are the American Society for Engineering Education, American Association for the Advancement of Science, and Early Birds. He was a Fellow of The Royal Aeronautical Society, England.

Lee S. Wallace

Leland Stanford Wallace, M.I.A.S., passed away at the Montifiore Hospital, Bronx, N.Y., on February 27, 1951.

A native of Ohio, Mr. Wallace was born in Jackson on March 5, 1893. He was a student from 1909 to 1913 at the Polytechnic Institute in Los Angeles and San Francisco, completing a course in mechanical engineering. For the next 2 years, he took a special arts course at the University of California.

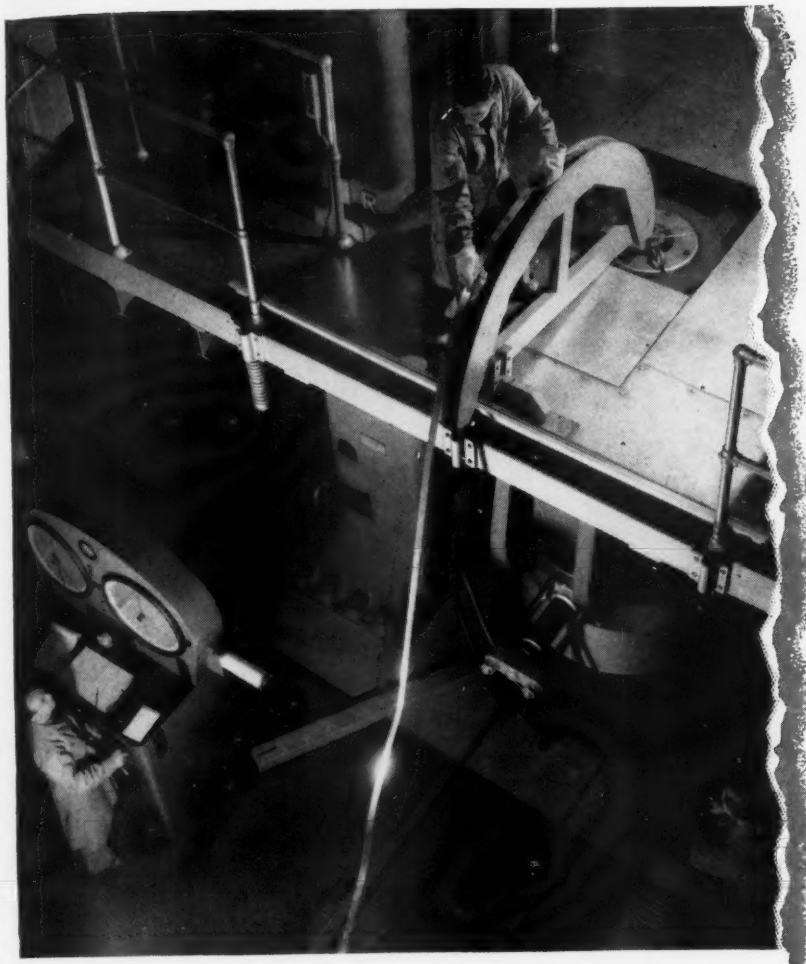
Mr. Wallace began his aeronautical career in 1909 when he started building gliders and flying them. Since that time, he had been engaged in various shop, field, and office capacities in the aeronautical industry. His work was related to many types of ships and the design of several aircraft engines, propellers, and instruments. Through the years, he had worked with Curtiss Airplane and Motor Company, Bird Aircraft Corporation, Canadian Car and Foundry Company, Wallace-Martin Aircraft Corporation, War Production Board, and Central Aircraft Corp.

Major Harold L. Wilson

Major Harold Lewis Wilson, U.S.A.F., T.M.I.A.S., was killed in the crash of a B-25 at Wright-Patterson Air Force Base, Ohio, on September 21, 1950. He was 31 years old.

Educated at Camp Hill (Ala.) High School and Alabama Polytechnic Institute, Major Wilson was granted a B.S. degree in Aeronautical Engineering from A.P.I. in June, 1941. Two months later, he enlisted as an Aviation Cadet in the U.S. Army Air Force and received training as a Bomber Pilot. During World War II, he served as Reconnaissance and Patrol Pilot on B-17's and B-24's, B-24 Instructor Pilot and Chief Flight Test Pilot, B-29 Airplane Commander in Training, and B-29 Airplane Commander in Combat. After nine missions over the Japanese mainland, he was returned to the United States and was appointed Director of the B-29 Airplane and Engine Mechanic School, Kessler Air Force Base, Miss.

After 2 years at the U.S.A.F.'s Institute of Technology at Wright-Patterson, A.F.B., Major Wilson was named Project Engineer, Bombardment Branch, in September of 1949. In this capacity, he specialized in the design and development of military-type aircraft. At the



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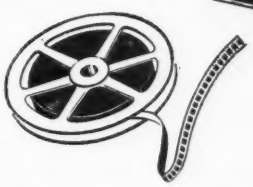

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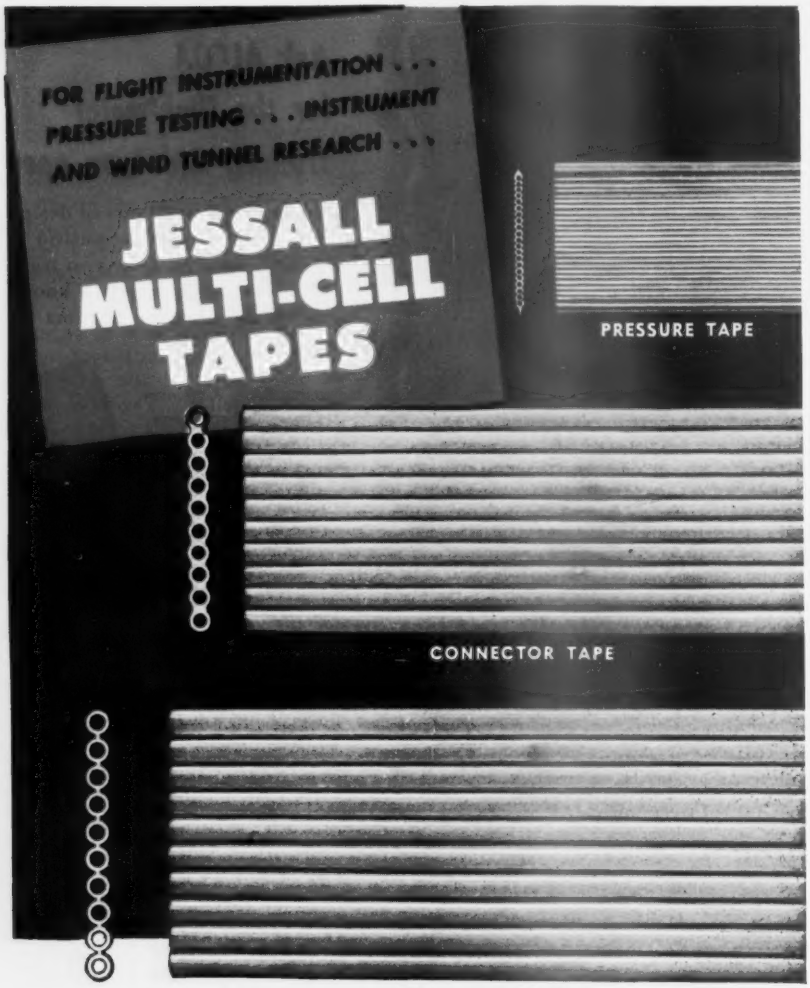

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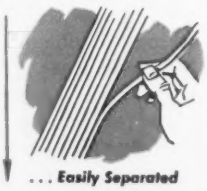
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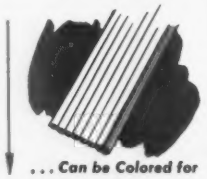
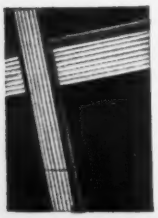

. . . Can be Colored for Easy Identification



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time of his death, he was attached to the Aircraft Projectile and Guided Missile Section at Wright-Patterson A.F.B. as Project Officer.

In addition to his military rating as pilot, Major Wilson also held a C.A.A. Commercial Pilot's Certificate No. 81353-41.

News of Members

▸ **Dr. Karl T. Compton,** F.I.A.S., Chairman, Massachusetts Institute of Technology, was one of seven Americans who were advanced from the rank of Chevalier to that of Officer in the French Legion of Honor for their help toward Franco-American understanding. The announcement was made during the recent visit to the United States of Vincent Auriol, President of France.

▸ **William G. Cornell** (M.), Development Engineer, Aircraft Gas Turbine Division, General Electric Company, was a recipient of the Charles A. Coffin Award, G-E's highest honor for meritorious accomplishments in aviation projects during 1950. Specifically, he and another development engineer were honored for their practical application of advanced technical skills in the concept and development of a novel axial-flow compressor.

▸ **Walter M. Fitch** (A.M.), XB-47 Flight Test Inspection, Wichita Division, Boeing Airplane Company, won the Olive Ann Beech Trophy in the 1950 Annual International Aeronautical Literary Contest conducted by the Women's International Association of Aeronautics. The trophy was awarded for his paper, "First Flights," in the Aviation History and Biographies classification.

▸ **C. R. Smith** (A.M.), President, American Airlines System, completed a 6-week tour of active duty with the U.S. Air Force on March 31. During that interim, he was assigned to the office of the Under Secretary of the Air Force as an adviser on military procurement.

Members on the Move

This section is for the purpose of giving information on the latest affiliations of I.A.S. members. All members are urged to notify the News Editor of changes as soon as they occur.

O. Goran Axell (A.F.), on leave of absence from the Swedish Air Force as Technical Assistant to the Director, Aeronautical Research Institute of Sweden;

(*Continued on page 44*)

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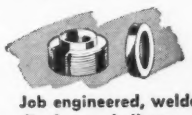

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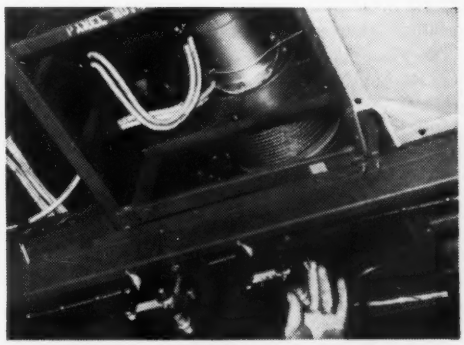

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Helicopter Society News

Western Regional Dinner Meeting

THE ENTIRE PACIFIC COAST helicopter industry opened its 1951 doors to business with a dinner meeting given by the American Helicopter Society at the Hollywood Roosevelt Hotel, Los Angeles, on March 19. This gathering, under the Chairmanship of C. M. Belinn, Vice-President of the A.H.S. Western Region, was composed basically of the three major elements that have spawned this revolutionary segment of the transport industry over the past several years. These three sections consist mainly of executives, scientists, pilots, and engineers of the three principal categories of the art: (1) the tightly scheduled carriers of air mail and cargo, such as Los Angeles Airways, pioneer southland operations; (2) the so-called nonscheduled carriers, whose chief interest lies in emergency flights, power-line patrol, crop dusting, and other sundry missions, represented by such well-known operators as Armstrong Flint Helicopters, Inc., Rick Helicopters, and U.S. Helicopters, Inc.; and (3) the military effort, particularly the helicopter groups of the "Leatherneck," the U.S. Marines. These groups were flanked by other military and civilian leaders in that field, such as the U.S. Air Forces, U.S. Coast Guard, U.S. Postal Service, Civil Aeronautics Administration, Lockheed Aircraft Corporation, County of Los Angeles, etc.

In opening the Forum, Chairman Belinn emphasized industry perspective in a short address titled "Where Have We Been, Where Are We, and Where Are We Going?" Mr. Belinn discussed these points:

(1) The relative degree of safety of single- versus multiengined transport helicopters for commercial passenger service.

(2) The suitability of transport helicopters in service or under development for all-weather operations.

(3) Foreseeable advances in the art over the next 10 years, including, among other things, the application of turbine and jet power and the commercial prospects for the convertaplane or some compromise between the helicopter and convertaplane.

(4) The specific advantages of transport helicopters over fixed-wing aircraft for short-haul passenger operations of up to, say, 100 or 150 miles.

(5) Specific recommendations as to what steps the various civil and military agencies of the Federal Government could take to accelerate the development and use of transport helicopters in commercial air-line operations.

Other major contributors to the event were a report on the utility of helicopters in the Marine Corps from Lt. Col. William Herring, of the recently reactivated El Toro Helicopter Air Base, and a detailed discussion of the Los Angeles County Master Plan of Heliports by Brig. Gen. William J. Fox, Director of Aviation, Los Angeles County.

The list of persons attending the American Helicopter Society Western Regional Dinner Meeting included: Lee Adams, Los Angeles Airways; C. M. Belinn, Los Angeles Airways; Stanley Brown, Los Angeles Airways; Martin J. Burke, Burke, Williams & Burke; Lt. Comdr. W. E. Chapline, Jr., U.S.C.G.; George L. Dillaway, Los Angeles Airways; Major J. R. Dyer, U.S.M.C.; R. K. Falconer, Rotor-Aids; Cal Ferris, Chief Pilot, Division of Fire Control, U.S. Forest Service; A. J. Fokker, Lockheed Aircraft Corporation; Dr. W. F. Hamilton, Flight Surgeon, Los Angeles Airways; Capt. E. E. Heller, U.S.A.F.; Lt. Col. G. W. Herring, U.S.M.C.; Phillip Hill, Postmaster for Santa Monica; Capt. J. W. Holman, U.S.A.F.; 2nd Lt. Len Hughes, U.S.A.F.; Fred Hunter, American Aviation Publications; Lt. (j.g.) I. J. Hynes, U.S.C.G.; R. J. Joy, U.S.C.G.; G. I. Kellogg, Chief Pilot, U.S.C.G.; W. P. Kennedy, Lockheed Aircraft Corporation; Karl Kernochan, Goodyear Tire & Rubber Company's Aviation Division; C. B. Kesselring, Los Angeles Airways; Lt. R. A. Kilgore, U.S.M.C.; Vaughn E. Krug, Pacific Helicopter Company; Lt. Comdr. G. H. MacLane, U.S.C.G.; C. E. Marthens, Rick Helicopter Company; Mr. Meunier, Rotor-Aids; Fred W. Milam, Los Angeles Airways; Don Milburn, Los Angeles Airways; Lt. (j.g.) R. M. Miller, U.S.C.G.; Gale J. Moore, Los Angeles Airways; Dr. F. N. Harris, Pasadena Chamber of Commerce; H. Niemczura, Sikorsky Aircraft Division, United Aircraft Corporation; D. A. Nystrom, Chief Pilot, U.S.C.G.; Capt. C. F. Rayner, U.S.A.F.; Robert E. Reedy, Lockheed Aircraft Corporation; J. J. Reinhardt, Los Angeles Airways; G. L. Reynolds, Forest Engineer, Angelus National Forest; J. S. Ricklefs, Rick Helicopter Corporation; J. E. Rothman, New York Airways; W. R. Sadler, Los Angeles Airways; Elmer Schlesinger, U.S. Helicopters, Inc.; J. G. Seward, Rotor-Aids; Robert Sheehan, Manager, Pacific Mutual Building Heliport; R. H. Sommers, Secretary, Aviation Committee, Los Angeles Chamber of Commerce; C.W.O. P. L. Sumners, U.S.M.C.; P. C. Thornbury, C.A.A.; Capt. S. V. Titterud, U.S.M.C.; Capt. R. F. Warren, U.S.M.C.; Langhorne Washburne, Hiller Helicopters, Inc.; and Richard H. Williams, Hughes Aircraft Company's Helicopter Division.

Seven additional persons were able to attend only the meeting itself. This list included: Fred Bowen, A-F Helicopters, Inc.; J. E. Douglas, American Helicopter Company, Inc.; Mr. Goodrich; William Hudson, C.A.A.; Dixon W. Kelley, Johnson and Higgins; Gilbert Magill, Rotorcraft; and Tom Self, *Aviation Week*.

E. J. HUBER
Publicity Chairman, A.H.S.

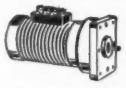
Members on the Move

(*Continued from page 42*)

and, currently, on leave of absence from the Aeronautical Research Institute as Research Contact Officer for Swedish aircraft and engine industries, Air Attaché Office, Embassy of Sweden, Washington, D.C. Formerly, Head, Project and Development Section, Royal Swedish Air Board, Stockholm.

RECEIVES S.A.E. AWARD

James C. Floyd (M.), Chief Design Engineer, A. V. Roe Canada Limited, was awarded the Wright Brothers Medal, commemorating pioneer American efforts in flying, by the Society of Automotive Engineers for contributions to technical literature and the design and development of jet-propelled aircraft. The selection of Mr. Floyd as its recipient is based specifically upon the excellence of a paper on "The Avro C-120 'Jetliner,'" prepared and presented by him before the S.A.E. Annual Meeting held in Detroit in January, 1950. Born in England 35 years ago and graduated by Manchester College of Technology in 1934, Mr. Floyd is first citizen of any foreign country to be accorded this honor. Presentation was made by the S.A.E. on April 18 at the 1951 National Aeronautic Meeting in New York.

The last word . . . . You've said the last word when you say it's made by Kollsman—you've said the last word about a miniature motor. Engineers who specify aircraft instrument  and control systems have looked to Kollsman for more than twenty years for the last word in accuracy, in surety of performance, in dependability.

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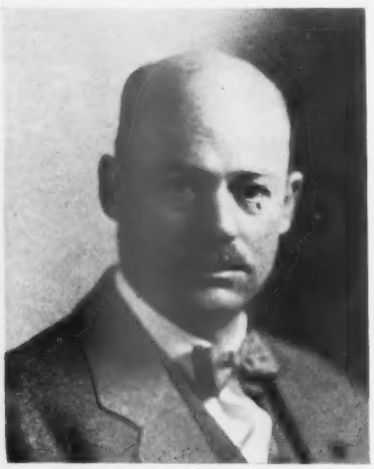

CHANGES AT M.I.T.

Dr. Charles S. Draper, F.I.A.S., (left), was appointed Head, Department of Aeronautical Engineering, Massachusetts Institute of Technology. He will succeed Dr. Jerome C. Hunsaker, Founder Member, First President, Fellow, and Advisory Council Member of the Institute, who asked to be relieved of administrative responsibilities for the Department. Dr. Hunsaker, who will continue as a professor until his retirement next year, founded in 1914 at M.I.T. the first professional course in aeronautical engineering in this country. M.I.T.'s Department of Aeronautical Engineering is the outgrowth of that graduate course established by Dr. Hunsaker, then on leave from the U.S. Navy. Prior to this appointment, which becomes effective July 1, Dr. Draper, Professor of Aeronautical Engineering, has been Deputy Head of the Department, as well as Director of the Instrumentation Laboratory. He will continue in this latter capacity for the present.

ACCEPTS NEW POST

Martin V. Kiebert, Jr. (M.), was recently appointed to the newly created post of Business Manager of Bendix Aviation Corporation's Research Laboratories. In his new capacity, he will administer various Government contracts and will be responsible for market research. Prior to accepting his present position, he was Manager and Director of Research, Telemetering Division, Raymond Rosen Engineering Products, Inc. Mr. Kiebert is Technical Consultant and Adviser on certain instrumentation problems to the Atomic Energy Commission, the Navy's Bureau of Aeronautics, the Research and Development Board, and the Air Materiel Command.

John D. Beadling (T.M.), Engineering Draftsman Class "B," Helicopter Division, Bell Aircraft Corporation. Formerly, Student.

Charles P. Brewer, Jr. (T.M.), now Junior Test Engineer, Wright Aeronautical Corporation Division, Curtiss-Wright Corporation.

Frances A. Bussink (T.M.), see Mrs. Frances A. Rittamel.

William J. Carry (M.), Vice-President, The BG Corporation. Formerly, Assistant to the President, BG.

Private Paul R. DesJardins, U.S.A. (T.M.), 9330 T.S.U., O.G.M.C., Redstone Arsenal, Huntsville, Ala.

Leon Lee Douglas (M.), Vice-President in Charge of Engineering, Piasecki Helicopter Corporation. Formerly, Chief Engineer, Piasecki.

Morris Feigen (M.), Associate Engineer, University of California at Los Angeles. Formerly, Senior Project Engineer, Southern California Cooperative Wind Tunnel.

John Gelb (M.), Staff Engineer, Kaman Aircraft Corporation. Formerly, Chief Engineer, Bowser Technical Refrigeration Company.

James R. Gohl (T.M.), Engineering Designer "B," El Segundo Division, Douglas Aircraft Company, Inc. Formerly, Postgraduate Student and Candidate for M.S. degree, University of Michigan.

R. H. Guthrie (M.), Executive Engineer, Canadian Pratt & Whitney Aircraft Company, Ltd. Formerly, Engineer, de Havilland Aircraft of Canada, Ltd.

G. O. Haglund (M.), Assistant Director, Aeronautical Research Laboratories, General Mills, Inc. Formerly, Manager, Engineering Physics Division, Frederic Flader, Inc.

Girvis E. Ledbetter (M.), Engineering Designer "B," Boeing Airplane Company. Formerly, Research Engineer, Aeronautical Engineering Department, University of Washington.

Edward A. Ledeen (M.), Mechanical Engineer, Haines Designed Products Corporation. Formerly, Field Engineer, Taller and Cooper, Inc.

Ludwig A. Majneri (A.F.), President and Chief Engineer, Aeroguild Inc., 11639 Klinger Ave., Detroit. Formerly, Vice-President and Chief Engineer, Warner Aircraft Corporation.

Michael Maletz (M.), Structures Engineer "A," Lockheed Aircraft Corporation. Formerly, Analytical Mechanical Engineer, Kearney and Trecker Corporation.

Carl J. Martin (T.M.), Aeronautical Engineer, U.S.A.F. Joint Long Range Proving Ground Division, Patrick Air Force Base, Fla. Formerly, General Manager, Maples Development Company.

James A. Martin (T.M.), Aeronautical (Aerodynamics) Research Intern, N.A.C.A., Muroc, Calif. Formerly, Engineering Draftsman "A," Douglas Aircraft Company, Inc.

Robert W. Prentice (T.M.), Mathematician, Long Beach Plant, Douglas Aircraft Company, Inc. Formerly, Engineering Aide, Public Works Department, Naval Air Station, Pensacola, Fla.

Private Joe D. Reynolds, U.S.A. (T.M.), Hq. & Hq. Co., 1 Bn., 155th Inf. Reg., 31st Div., Fort Jackson, S.C. Formerly, Draftsman, Beech Aircraft Corporation.

NEW POST

George F. McLaughlin (M.) has joined Facts, Inc., as Head of the new Aviation Research Division. Active in the aviation field since 1916, he has been an Editor (for 17 years) on Aero Digest, Vice-President and Technical Director for Jordanoff Aviation Corporation, and Director of Technical Publications of McLaughlin Research Corporation. He began his aeronautical career as a designer. Mr. McLaughlin is a member of the Early Birds and is one of the eight organizers of the Aviation Writers Association.

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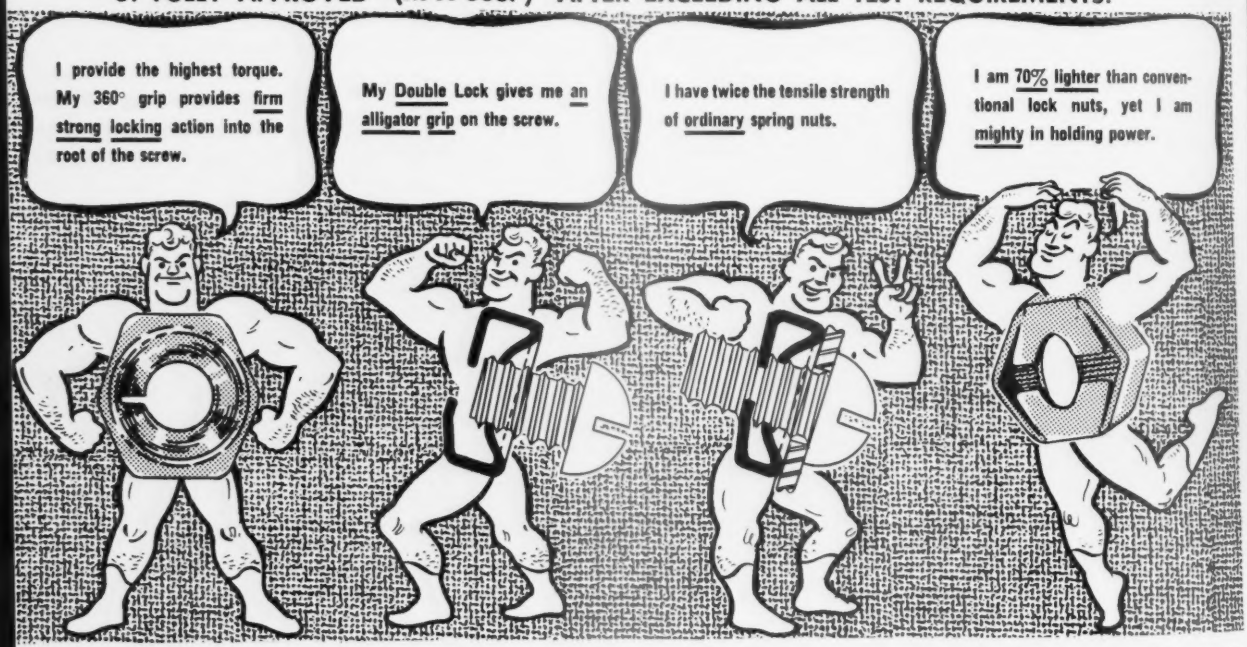
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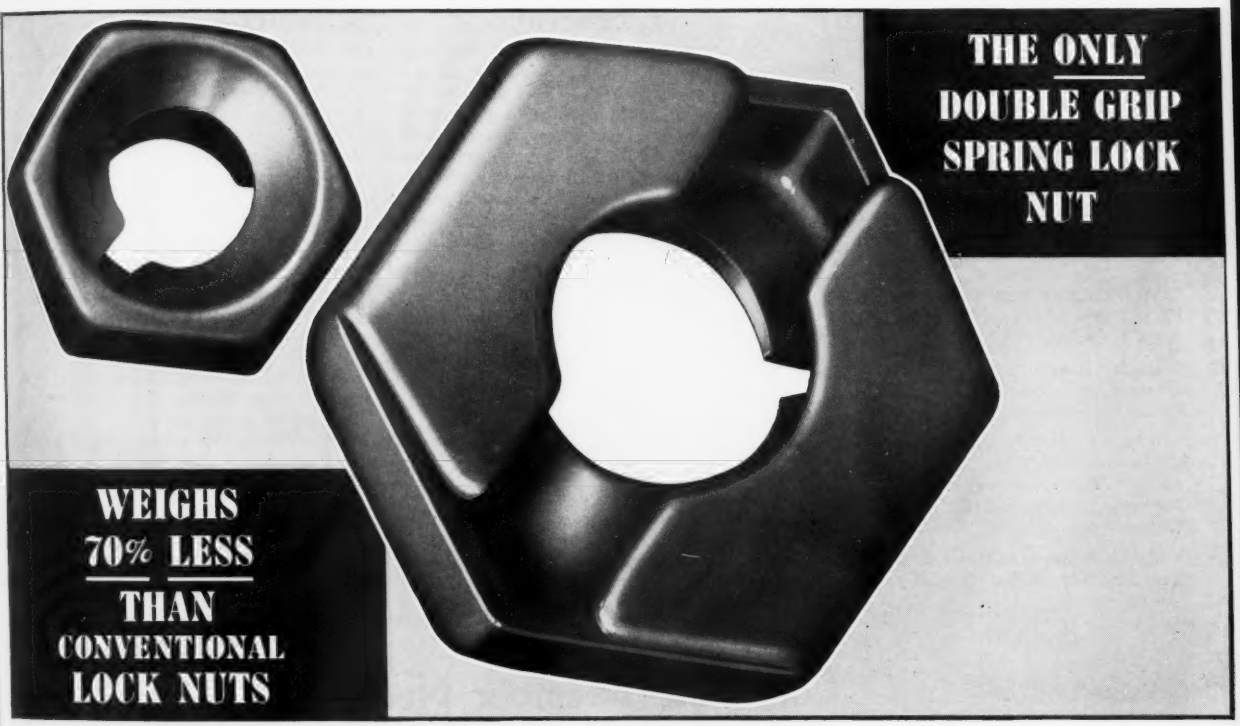

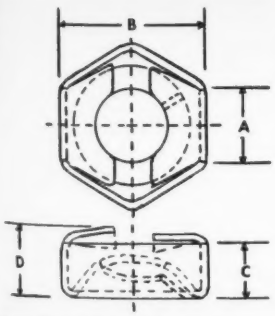

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SCREW SIZE	PART NUMBER	A	B	C	D	MATERIAL THICKNESS T
¼-20	M 350-1	15/64	7/16	5/32	.200	.020
10-24	M 350-2	3/16	3/8	1/8	.1875	.020
10-32	M 350-3	13/64	3/8	1/8	.165	.016
8-32	M 350-4	11/64	11/32	1/8	.155	.016
6-32	M 350-5	9/64	5/16	3/32	.140	.016

CORPORATION

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JOINS MICHIGAN FIRM

Gene T. Neudeck (M.) resigned from his former position as Sales Engineer, Aeroproducts Division, General Motors Corporation, to become General Sales Manager of the V. L. Graf Company. Graduating from the University of Michigan in 1941 with an Aeronautical Engineering Degree, Mr. Neudeck had been with Aeroproducts for the intervening 10-year period.

NAMED TO NEW POSITION

J. Louis Reynolds (M.), who has been Vice-President—Sales of Jack & Heintz Precision Industries, Inc., was named Assistant to the President and was assigned to the concern's expanding program of field engineering research and development. His headquarters will be in Los Angeles. Before joining Jack & Heintz more than 6 years ago, he was with the Bell System and Eclipse-Pioneer Division of Bendix Aviation Corporation.

JOINS JACK & HEINTZ

E. C. Sulzman (M.) resigned from his position as Sales Manager for Wright Aeronautical Corporation to become Vice-President and General Sales Manager of Jack & Heintz Precision Industries, Inc. A Cornell University graduate, he was at one time identified with Western Electric and Worthington Pump Works.

Mrs. Frances A. Rittamel, nee Bussink (T.M.), now Mathematician "A," Hughes Aircraft Company.

Dexter Rosen (A.F.), now Field Test Director, Bell Aircraft Corporation, Holloman Air Force Base, N.M.

Private Stanley P. Sadlocha (T.M.), 790 Quartermaster Reclamation and Maintenance Company, Camp Atterbury, Ind. Formerly, Mechanical Engineer, Shreve Walker & Associates.

Martin A. Snyder (T.M.), Senior Flight Test Engineer, Flight Test Department, Bell Aircraft Corporation. Formerly, Flight Test Engineer, Flight Test Division, Naval Air Test Center, Patuxent River, Md.

Glenn A. Socks (T.M.), now Engineering Technician, Lockheed Aircraft Corporation.

Henry H. Tompkins (T.M.), Aerodynamicist "B," Stability and Control Group, Aerodynamics Section, El Segundo Plant, Douglas Aircraft Company, Inc. Formerly, Graduate Student, Rensselaer Polytechnic Institute.

Victor Warshaw (M.), Aeronautical Designer (Electrical and Cockpit), Bristol Engineering Corporation. Formerly, Electrical Designer, Piasecki Helicopter Corporation.

Raymond A. Young (A.F.), Head, Helicopter Design Section, Research Division, Bureau of Aeronautics, U.S. Navy. Formerly, Head, Air Loads Unit, Structures Branch, Design Elements Division, BuAer.

Raymond W. Young (M.), Vice-President of Engineering, Reaction Motors, Inc. Formerly, Wright Aeronautical Corporation.

Corporate Member News

• **Aeroproducts Division, General Motors Corporation** . . . A "ground-breaking" ceremony on April 4 officially started the plant-expansion program. This project, which will more than double the present available floor space, is scheduled for completion around the end of this coming July.

• **Aircraft Gas Turbine Divisions, General Electric Company** . . . According to an announcement on March 24, the Atomic Energy Commission has authorized negotiation of a contract with the Aircraft Gas Turbine Divisions for the further development of a nuclear reactor for aircraft.

• **AiResearch Manufacturing Company, Division of The Garrett Corporation** . . . Two versions of the small gas-turbine engine are now in production. One produces compressed air equivalent to 65 air hp.; the other produces up to 84 shaft hp. The units, about the size of a hand valise and weighing between 150 and 175 lbs., were developed as a basic power source of an all-pneumatic system to start jet and turboprop engines and to operate major accessories . . . An auxiliary power package for guided missiles, incorporating a tiny 60,000 r.p.m. axial-flow turbine, is about the size of a milk bottle. As a secondary source of power within a missile, it will operate such vital elements as stabilizers and air surface and guidance controls during supersonic flight. The power package consists of a partial-admission axial-flow turbine, a reduction gearbox, a 12,000 r.p.m. induction generator, and a gear-type hydraulic pump . . . A contract for supplying complete air-conditioning and pressurization systems for the first 100 new Convair Liner 340's was awarded to AiResearch. When the job is completed, each Convair Liner will carry 23 different AiResearch items.

• **American Airlines System** . . . The Board of Directors has approved the additional purchase of three DC-6A Airfreighters. These three, scheduled for delivery in 1952, will increase American's Airfreighter fleet to 16. Also, on order from Douglas Aircraft Company, Inc., are 17 DC-6B passenger planes with enlarged cargo compartments. The DC-6B's will be delivered this year.

• **Beech Aircraft Corporation** . . . The Royal Canadian Air Force has announced that the twin-engined Beechcraft Model D18S will be used for pilot training, navigation training, and short-range communications work.

• **Bell Aircraft Corporation** . . A $3,000,000 helicopter engineering and manufacturing plant will be built on a 55-acre tract of land located between Fort Worth and Dallas. Engineering and architectural contracts have been let for the design.

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. . . measures pressure or flow and transmits a proportionate signal to remotely-located recording or control devices.

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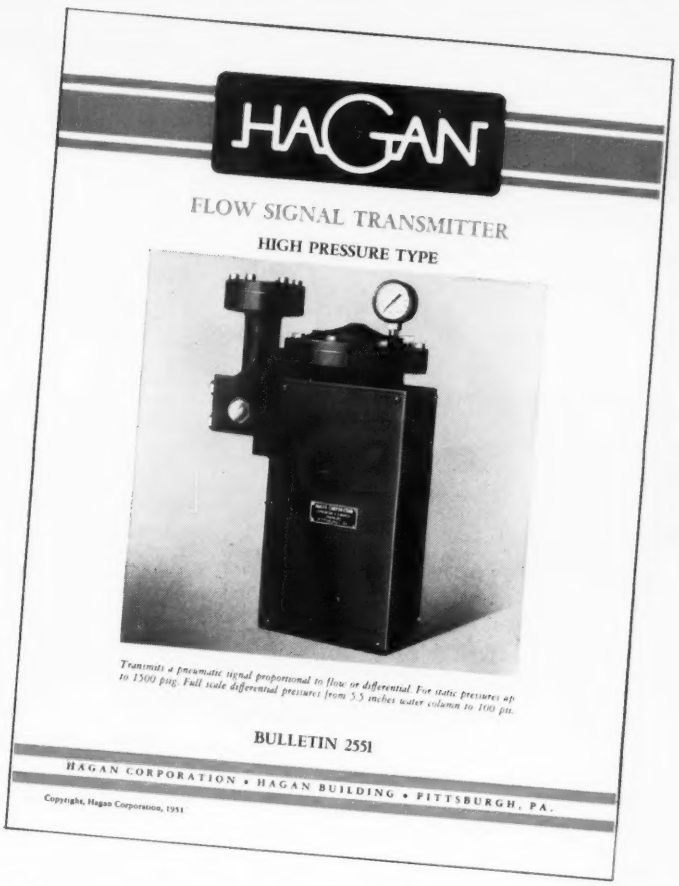
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Performance compromises necessarily inherent in many previous designs have been eliminated.

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The first unit of the new facility will have 200,000 sq.ft. with provisions for future expansion. According to present plans, all helicopter activities will be transferred ultimately to Texas.

• **Boeing Airplane Company** . . . A new method for producing cam tracks, used in raising and lowering the wing flaps on the B-47 Stratojet, is said to reduce the time so required by 75 per cent. The former procedure of turning the cam tracks out in triplicate from 75-ST aluminum extrusions with a hydraulically controlled duplicator has been replaced. The new technique involves first the machining of the raw extrusions to engineering dimensions on a Farnham mill and then their stretching and shaping on a large Hufford stretch press. By the older method, three cam tracks can be turned out in 4 hours; by the newer process, one track can be produced in 20 min., or at the rate of twelve in the older 4-hour period . . . A six-pen graphic flight recorder, dubbed "Wigglin' Willy," has been developed at Boeing to give engineers immediate flight-test data relative to time intervals, air speed, angle of pitch, normal acceleration, elevator position, and elevator hinge moment (correct). Each pen describes that particular airplane movement to which it is linked, and the information is written by all six pens on a moving roll of graphic paper 150 ft. long. This machine has four speeds, ranging from $1\frac{1}{2}$ to 75 in. per min. . . . The first aerial refueling of the B-47 Stratojet medium bomber using the Flying Boom system was revealed on March 15. A KC-97A Stratofreighter was used as the tanker airplane . . . The first TB-50D navigator-bombardier trainer was delivered March 25 to the U.S.A.F. This extensively modified B-50 is to be used in training crewmen who must serve in three capacities on high-speed jet bombers: bombardier, navigator, and radar operator. The "Flying Schoolhouse" is expected to turn out annually about 650 officer-students, who are designated by the Air Force as navigator-bombardier "1037's."

• **Brown Instruments Division, Minneapolis-Honeywell Regulator Company** . . . The automatic compiling of two measurements and plotting of a curve to show their interrelationship—namely, $Y = f(X)$—is made possible by a new electronic instrument, the Brown ElectroniK Function Plotter. The instrument incorporates two measuring systems, one of which actuates the recorder pen while the other motivates the instrument chart; this results in a curve that consistently evaluates one variable in terms of another. Measurements over the entire curve are continuous; no interpolation is needed to complete data between points of measurement.

• **Consolidated Vultee Aircraft Corporation** . . . Construction on the new $650,000 engineering test laboratory at the Fort Worth Division was begun in early April; completion is expected in August. The laboratory will be able to duplicate practically any environmental condition on or above the earth, and in a matter of seconds, climatic conditions of the desert, jungle, or polar regions can be simulated. There will be 45,000 sq.ft. of working space . . . The KB-29 Superfortress re-

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World's First Air Dropped Bridge Spans Carried By 119's To Chosin Reservoir Battle
HQS, FEAF CARCOM, (A.T.) The world's first air drop of a bridge was made today by aircraft of the FEAF's Combat Cargo Command, was eight spans totaling 16 tons were parachuted near Kotori-Ri in North Korea.
United States Marines, fighting bitterly against hordes of Chinese Communist Troops in the frozen north, gazed up in awe as the huge C-119 "Flying Boxcars" of the 314th Combat Cargo Wing broke through an overcast and spilled out the huge pieces of equipment. Large 100 foot parachutes supported the spans as they drifted slowly down, landing near the determined leathernecks.
Mission successful, pilots returning to this

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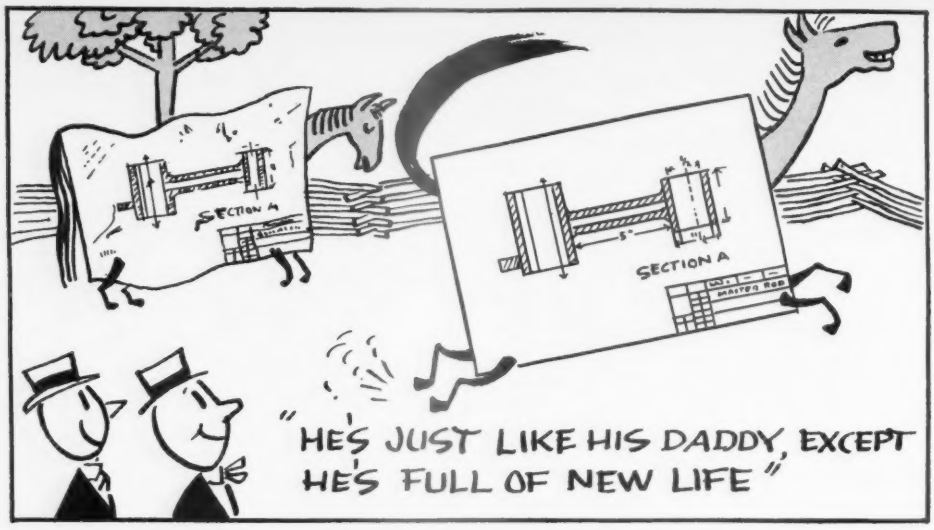

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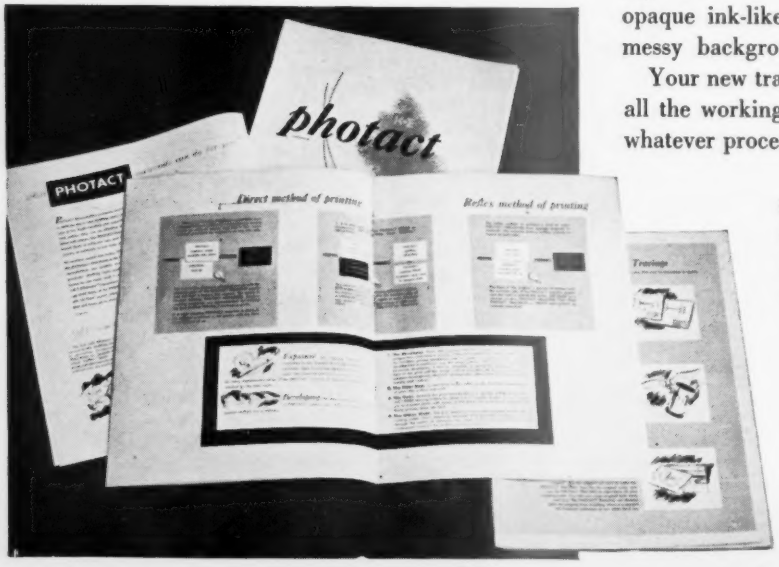

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K&E offers a booklet on PHOTACT materials that may give you some useful ideas. It explains the simple process. Ask your nearest K&E Distributor or Branch, or write to the main office at Hoboken.

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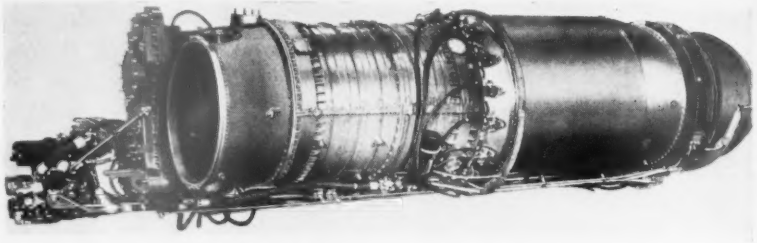
fueling airplanes or tankers will carry a pair of lightweight fuel tanks, made by The Goodyear Tire & Rubber Company, in the fore and aft parts of the bomb-bay section. These droppable tanks will be used in the in-flight refueling of the B-50 medium bombers . . . Millions of dollars' worth of B-36 parts are being subcontracted in eleven states, according to a recent announcement. In addition, Convair obtains materials and services for B-36 production in 36 states and the District of Columbia. These figures do not include the Government-furnished equipment.

• **Cornell University** . . . A special program of advanced study for teachers of engineering will be offered during Cornell's Summer Session, July 2–August 11. The program will include six courses: Elementary Mechanics of Materials from an Advanced Standpoint; Applied Elasticity; Theory of Elastic Stability; Plasticity in Engineering; Advanced Structural Analysis; and Aircraft Structures. Each course carries with it 3 semester hours of credit; any two may be taken during the summer session. Inquiries re further details of the program should be directed to Prof. H. D. Conway, West Sibley Hall, Cornell University, Ithaca, N.Y.

• **Douglas Aircraft Company, Inc.** . . . The new Tulsa, Okla., plant is scheduled to take on a Boeing B-47 modification program. This will permit the training of workers before the actual B-47 production schedule commences. Douglas took this plant over on March 1.

PILOT EJECTION TOWER

This 100-ft. Tripodal tower built by Allis-Chalmers Manufacturing Company from some 28 tons of steel is designed to orient cadets in pilot-ejection procedures. Placed in use on February 28, it is now a regular part of the U.S.A.F. training program at Williams Air Force Base, Ariz. The seated cadet is fired up the track of the 20°-angle tower by a 37-mm. catapult shell, the force of which carries the student to a height of 60 ft. Seat and pilot are shot to a 40-m.p.h. start in the first 60 in. of movement by the shell. The overall speed is about 60 ft. per sec. A cable lowers the pilot back to the ground.



MOST POWERFUL JET IN PRODUCTION

The J-40-WE-6 turbojet aircraft engine, manufactured by the Aviation Gas Turbine Division, Westinghouse Electric Corporation, is believed to deliver more thrust than any other jet engine known to be in production today. The J-40, which has a split air intake, is completely controlled by an electronic control system that leaves the pilot free for combat duty. The engine is slated for installation in the Navy's newest fighter aircraft.

• **Fairchild Aircraft Division, Fairchild Engine and Airplane Corporation** . . . Techniques used by Fairchild to obtain outstanding results from an International Business Machine Electronic Calculator were observed and recorded by Robert Loewy (T.M.), of Cornell Aeronautical Laboratory, Inc. Test programs were programmed and processed, and electrical circuits used in making calculations on the C-119 were reproduced and forwarded to the Laboratory for study. According to an announcement, the results of this study will aid Cornell aeronautical engineers in making calculations similar to those in operation at Fairchild . . . A C-119 Packet recently completed a 3-month series of suitability tests for troop and cargo transport operations under the extremely low arctic temperatures at Ladd Air Force Base, Alaska.

• **Federal Telephone and Radio Corporation** . . . An improved noncontaminating-type cable jacket for use under arctic or high-altitude flying conditions by F.T.R.C. and Federal Telecommunication Laboratories, Inc., associates of International Telephone and Telegraph Corporation. This new thermoplastic IN-111D cable jacket was designed primarily for use in high-frequency RG/U cables. It is claimed that this IN-111D jacket is able to withstand flexing at temperatures of −40°C. after a 14-day aging at +80°C.

• **General Electric Company** . . . New aircraft equipment service facilities have been established at two G-E Service centers in Los Angeles and Dallas. The overhaul and modification of the J-47 turbojet, as well as armament overhaul and instrument repair, will be handled at Los Angeles. The Dallas facilities will take care of the modification and overhaul of the B-36 fire-control system and will make modifications resulting from early flight tests and flight experience . . . Major components of G-E's J-47 jet engine will be produced by Willys-Overland Motors, Inc., at their recently acquired plant at Anderson, Ind.

• **The B. F. Goodrich Company** . . . A new version of the electric heating pad designed specifically to keep ice from forming on wings and other exterior surfaces can be made in any shape or size to fit such parts as antenna masts, propellers, air scoops, spinner domes, and cowl rings.

• **Hamilton Standard Division, United Aircraft Corporation** . . . A 19-ft. aircraft propeller, developed under U.S. Air Force sponsorship for power plants delivering over 5,000 hp., is being tested at the U.S.A.F.'s Air Materiel Command. This particular prop is the third one of Hamilton's line of turbine propellers (Turbo-Hydromatics) to reach the stage of Air Force or Navy Testing after extensive endurance tests at the factory . . . According to schedule, all operations will be headquartered in a larger plant by the early part of next year. The new plant, erected by United Aircraft, is located at Bradley Field, Windsor Locks, Conn., just 14 miles away from their present location in East Hartford. The new building will be a one-floor structure of steel-girder and reinforced-concrete construction, with 500,000 sq.ft. of production area plus considerable office space.

• **Walter Kidde & Company, Inc.** . . . A visual smoke detector for aircraft gives promise of increased protection against fires in commercial air liners. Small-bore tubing connects the detector, which fits into any standard instrument panel, with the cargo compartments. When the air from these compartments is free of smoke, the detector's two viewing windows show up as "black chambers" through which "invisible" beams of light pass. If, on the other hand, the air from the cargo compartments contains even a small trace of smoke, the beams of light (one in each viewing chamber) become visible and cause that smoke to show up as bright streaks. A flasher unit is incorporated that permits the light beams to flash on and off, thus attracting the pilot's attention. Any burned-out signal bulb and flasher unit can be replaced within a matter of seconds by the pilot.

• **The Glenn L. Martin Company** . . . The U.S. Air Force has tagged the American version of the English Electric B.2 Canberra as the B-57A. The B-57A is to be manufactured by Martin, according to present plans.

• **Minneapolis-Honeywell Regulator Company** . . . An agreement has been completed to perform consulting services to Westinghouse Electric Corporation's Atomic Power Division. Under its terms, Honeywell engineers of the Valve Division will act as consultants in valve problems arising in the Westinghouse program.

• **Northrop Aircraft, Inc.** . . . According to an announcement, a successful method for distinctly lowering the number of decibels in the roar of afterburner-equipped air-

More Power for the world's largest bomber

Biggest in size and tops in performance, the Air Force's B-36D long-range bomber, built by Convair, can speed more than 435 miles per hour, above 45,000 feet.

. . . THERMOFLEX BLANKETS shield 4 new jets added to B-36D

Four new J-47 turbojet engines have recently been mounted under the wings of the Convair-built B-36D to nearly double the available horsepower and give this 179-ton sky giant unparalleled performance possibilities.

Shielding its two power-pods from the searing heat generated by the jet engines are Thermoflex* Blankets—the same highly efficient Thermoflex insulation that is standard protection for most other first-line Navy and Air Force jets today.

These flexible blankets meet the most critical thermal and physical requirements for modern jet design. The blanket is fabricated with the Thermoflex felt sealed between sheets of corrosion-resistant Inconel or stainless steel foils, which are then edge-folded and seam- or spot-welded.

The inner foil on all Thermoflex Blankets is specially grooved to facilitate installation, and insure precision fit around cylindrical and conical surfaces. Careful attention is also given to the precise location of cutouts for thermocouple leads and fuel, air, igniter and hydraulic lines, which may be clip-mounted directly on the blanket.

Thermoflex Blankets are custom made to insulate the turbine casings, exhaust cones, afterburners and tail pipes of turbojet, turboprop and auxiliary power units. Special preformed shapes are also available to insulate, protect and fireproof heating systems, de-icing ducts, fluid storage tanks and many other applications.

For the latest data on Thermoflex Blankets, write for new booklet AV-1A, "Johns-Manville Aviation Products." Address Johns-Manville, Box 290, New York 16, N. Y.

*Reg. U. S. Pat. Off.

NEW! RF-300 THERMOFLEX FELT

This homogeneous refractory fibre provides exceptional thermal efficiency, greater flexibility and a *25% saving in weight over previous insulation blanket fillers.* Write for complete details.

JOHNS-MANVILLE JM PRODUCTS **Johns-Manville** **PRODUCTS for the AVIATION INDUSTRY**

craft on ground runs has been developed. A muffler shroud fitting snugly around the jet plane is said to reduce the speed of the jet blast to about 120 m.p.h. and to lower the temperature of the blast to approximately 500° . . . Testing programs of the F-89 Scorpion have been conducted at two major Air Force bases. At Edwards A.F.B., the F-89's were flown in accelerated service tests, while other production models of the F-89 were being shaken down in tactical suitability tests at Eglin A.F.B.

• **Pan American World Airways, Inc.** . . . Officials from P.A.A.'s three divisions and the New York headquarters are planning to improve and standardize passenger service throughout the entire air-line system. Another group of officials are outlining methods of standardizing all engineering and technical procedures.

• **Pratt & Whitney Aircraft Division, United Aircraft Corporation** . . . When United Aircraft's Hamilton Standard Division completes its projected move from its present East Hartford facilities to new quarters now under construction at Bradley Field, Windsor Locks, Conn., P. & W. will occupy and enlarge the old Hamilton plant, thus gaining the advantage of 500,000 sq.ft. of production area on its own lot. In addition to this increase in floor space, another building is being constructed at North Haven, Conn., just south of the Wallingford town line. This New Haven plant will be a satellite of the P. & W. operations in East Hartford and will manufacture aircraft gas-turbine engine parts.

• **A. V. Roe Canada Limited** . . . To combat ice formation on the compressor blades of aircraft gas turbines, a method of providing internal electrical heating of the blade surface has been developed.

• **Trans World Airlines, Inc.** . . . As of April 29, both the International Operations and International Cargo Service are operating out of New York International Airport (Idlewild).

• **Servomechanisms, Inc.** . . . Standard components will be handled by a New York City dealer, Control Systems Company, 445 W. 23rd St.

• **Standard Oil Company of California and United Air Lines, Inc.** . . . An aviation gasoline contract amounting to more than $25,000,000 was recently signed. This contract, which becomes effective January 1, 1952, covers the gasoline needs of United for the years 1952–1954 inclusive. The area involved runs between Salt Lake City and the West Coast, the length of the Pacific Coast, and from California to Hawaii.

• **Vickers Incorporated** . . . Bulletin A-5200, *Vickers Hydraulic Equipment for Aircraft*, now available, summarizes technical information on Vickers' complete line of products for the aircraft industry. Inquiries re this bulletin should be addressed to Thos. B. Doe, Jr., Manager, Aircraft Product Sales, Vickers, Inc., 1414 Oakman Blvd., Detroit 32.

• **Westinghouse Electric Corporation** . . . A 5-kw. radio-frequency generator for industrial applications where relatively small parts are to be surface hardened, annealed, brazed, or soldered is now available. The unit is designed either for production-line operation or for small-lot operation. A single generator may be used for several kinds of work by changing the heating coil and fixture that attach at the front or top of the unit.

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special application MOTORS

May Be YOUR Answer to Lower Costs, Better Product Performance

You may find, as have many other designers of motor-driven products, that the use of Lamb Electric Motors will enable you to reduce costs as well as increase product appeal.

Specially engineered for each application, Lamb Electric Motors make available the following six important advantages:

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1. Reduced costs, weight, space.
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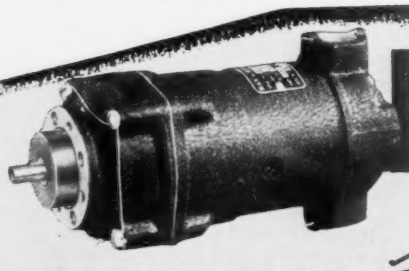
3. Thorough dependability.

IN THE PRODUCT—
4. Better performance.
5. Improved eye appeal.
6. Compactness, less weight.

Our engineering department will welcome the opportunity to work with yours —while your product is still in the design stage—to help obtain these results.

THE LAMB ELECTRIC COMPANY
KENT, OHIO

Double shaft extension motor for flap control on small aircraft and other dual uniform control applications.



Planetary inbuilt speed reducer permits a straight-line drive, symmetrical construction, insures good performance.

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SPECIAL APPLICATION FRACTIONAL HORSEPOWER MOTORS

Attention Members!

All members of the Institute are invited to submit material concerning their activities for publication in the "News of Members" columns of the *Aeronautical Engineering Review*. Responsibility for new developments, awards or honors received, and appointments to new or additional positions are some of the items that your editors believe are of interest to other I.A.S. members. A brief letter or postal card giving exact details will be sufficient. Photographs accompanying news items will be welcomed and will be used where practicable.

Items submitted will be considered on the basis of their timeliness and general interest. Correspondence should be addressed to the News Editor, *Aeronautical Engineering Review*, 2 East 64th St., New York 21, N.Y.

HOW TO GIVE LONGER LIFE AND BETTER PERFORMANCE TO AIRCRAFT GAS TURBINES

KENTANIUM for Vital Components WILL HELP

Longer service life for aircraft gas turbines of current design operating at 1500°F can be predicted with reasonable certainty when vital components are made of Kentanium, the distinctive heat-resistant material. Extensive experimental work in this field has produced noteworthy results.

Improved service life performance with standard power units using Kentanium should encourage and stimulate development of engines operating at higher temperatures to attain the advantages of greater thermal efficiency with maximum power in minimum size units.

Kentanium will resist oxidation at 1800°F to 2200°F for long exposures, and up to 4500°F for short exposures . . . It weighs only ⅔ as much as steel and conventional alloys, and has 2 to 3 times their resistance to deflection under load . . . Its ability to withstand thermal shock is noteworthy and its strength at elevated temperatures is outstanding . . . In Stress-to-Rupture characteristics it is superior to the best currently-used alloys at all temperatures from 1500°F up.

Kentanium—developed and produced exclusively by Kennametal Inc.—is chiefly titanium carbide, with small percentages of other refractory carbides, and nickel as the auxiliary metal, or "binder."

Neither tungsten nor cobalt is required.

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Our Engineers will be glad to confer with you regarding the applicability of Kentanium to your turbo-prop or turbo-jet engines.

KENTANIUM

- **Withstands OXIDATION**
- **Retains GREAT STRENGTH at HIGH TEMPERATURES**

(contains no Cobalt or Tungsten)

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Meet Your Section Chairmen

Stanley W. Smith

Buffalo Section

Stanley W. Smith, born in Clarkson, N.Y., on February 26, 1910, has been a devotee of the "aeronautical arts" since he was about 18. However, his initial interest antedates this, for he writes: "The study and development of aviation was of great interest to me throughout high-school days and was possibly further increased by my airplane model-building activities during that period." He became an active Gliding and Soaring Pilot in 1930 and currently holds certificates as a Commercial Glider and a Private Airplane pilot.

During the years that followed his graduation from the University of Michigan in 1934 with B.S. degree in Aeronautical Engineer, Mr. Smith was in the employ of Bowlus-duPont Sailplane, Inc., International Business Machines, and the New York State Aviation Schools. He was a Designer with the first two organizations named and a Teacher and Supervisor with the third.

Mr. Smith has been with Bell Aircraft since 1939. Initially hired as a Stress Engineer, he was promoted to Static Test Engineer; Project Stress Engineer on the XP-77 (an all-wood fighter plane); Structural Research Engineer; Preliminary Design Engineer; Project Engineer on the X-1 (the world's first supersonic aircraft); and, finally, in February, 1946, to his present position as Project Engineer on the X-2. Aside from the obvious fact that he is in charge of the design and development of the X-2, little can be said of his work; the Air Force has maintained a blanket of security around this supersonic research ship.

Mr. Smith and his wife, the former Frances E. Brown, whom he married in August, 1934, are the parents of three sons and a daughter, ranging in age from $1\frac{1}{2}$ to 13 years. First there is Peter W., aged 13; then comes Patricia, a young lady of some 10 years; Jeffrey A., aged 3, follows next; and Joel P., aged $1\frac{1}{2}$, "brings up the rear."

Queried about any incidents that might stand out in his memory as being of particular interest, Mr. Smith replied: "From the professional standpoint, probably the most interesting episodes have been in connection with the development and testing of the X-1 and X-2 airplanes. From the nonprofessional standpoint, I think that the experiences and the people met in connection with gliding and soaring have been most outstanding. One high point occurred in 1933 when I was able to win the National Soaring Championship at Elmira. In the following year, I took part in the experimental operation of a triple airplane-towed glider train between New York and Washington and return. It has been most interesting to watch and take part in the rapid advancement in soaring performance in this country in the past 20 years. In 1936, I was awarded the fourth Silver C Soaring Award to be won in this country. The three pilots earning this award earlier have all lost their lives in flying accidents in recent years, leaving me the ranking Silver C Pilot in the country."

In addition to the Institute, Mr. Smith is affiliated with the Aero Club of Buffalo, Western New York Weather Society, Quiet Birdmen, and Soaring Society of America.

John A. Stern

San Francisco Section

John A. Stern first got the idea of a career in aeronautics while he was visiting in the north country back in 1934. There he had the opportunity of watching the Bush Pilots in action and in due time became greatly impressed with the potential of aircraft. He was pretty well "sold" on aviation after that.

In September of the following year, he matriculated at the University of Chicago and was graduated from there 4 years later with a B.S. degree. The next 2 years were spent at the Massachusetts Institute of Technology. Immediately upon his graduation from M.I.T. with an M.S. degree, he was commissioned an Ensign in the U.S. Navy. He was assigned during a greater part of World War II to the Assembly and Repair Department, Quonset Point Naval Air Station, R.I., as Planning Superintendent. He received his discharge in 1946 with the rank of Lieutenant Commander.

Mr. Stern has been with United Air Lines, Inc., since that time. As an Aeronautical Engineer, his duties consist of calculating the performance data for commercial-type aircraft, assisting in the preparation of instructions for operating personnel, and checking to see that these instructions comply with existing legal requirements.

The U.S. Navy must have been an exciting place for Mr. Stern. Aside from the obvious interest that would be aroused by his assisting in the development and installation of rocket-launching equipment in Naval fighter and patrol aircraft, the Navy was where he met his wife, Elizabeth Hindson, who was also serving in the Navy as a Wave. They were married in October, 1945, and now have two children—Tommy, aged 4, and Jimmy, aged 2. Mr. Stern spends as much of his free time as possible playing with his boys, working in the garden, swimming, and building model airplanes.

Photo courtesy of *The Aeroplane*, London

Trans-Atlantic Teamwork . . . The twin-jet Canberra, being groomed to bolster our tactical air power, is a working example of British-American cooperation. Originally designed in England as a high-altitude radar bomber, its flight tests proved it to be as effective at low-level operations. Now, a night intruder version of this light jet bomber will be added to our own Air Force, built by Martin under license from English Electric Co., Ltd.

The Korean conflict has re-emphasized the importance of tactical air power in low-level support of ground troops. To this mission, the Canberra brings exceptional maneuverability at high combat speeds, and at low levels and low speeds . . . ability to whip around like a fighter and turn with the best of modern aircraft . . . ability to carry a potent, destructive wallop!

Martin AIRCRAFT

Builders of Dependable Aircraft Since 1909

THE GLENN L. MARTIN COMPANY, Baltimore 3, Md.

I.A.S. Sections

Baltimore Section

M. F. Taylor, *Secretary*

The February 27 meeting was held on The Johns Hopkins University's campus. Hans Multhopp, Design Engineer, The Glenn L. Martin Company, lectured on "Engineering and Science in Germany in World War II."

The speaker is especially qualified to talk on this interesting subject. During the recent world conflict, he was Chief of Aerodynamics and New Design, Focke-Wulf Aircraft Company, and held membership in the German Academy for Aeronautics. From 1946 to 1950, Mr. Multhopp lived in England where he served as a member of the Royal Aircraft Establishment at Farnborough. During this time, he was also on the Staff of the London University. Recently, he joined The Glenn L. Martin Company in this country as Design Engineer on new projects.

The thesis of Mr. Multhopp's enlightening talk concerned the basic and timely problem of achieving an optimum utilization of technically trained man power in organizing a military economy. In this connection, the particular failure of the German High Command in World War II was presented in a penetrating analysis by the speaker.

Introducing his lecture with a résumé of the economic conditions prevailing in Germany after World War I which precipitated the successful rise of Nazi power, Mr. Multhopp went on to explain the unfavorable influence of the military and political leaders on the state of the country's science and engineering. The man-power situation in the field of science and engineering was known to be rather tight before the war. The older generation had been expended during the first World War, and the anti-intellectual attitude of the Nazis had discouraged thoroughly the studying of the more rationalistic subjects. Thus, the scientific and engineering population in Germany before and during World War II consisted almost entirely of people born between 1901 and 1913. Most of them had no experience in any military service; this was considered by the speaker as one of the reasons for the particular success of German rearmament, which began in 1934. Typical in this connection is the ironical fact that the technological progress was most remarkable in those fields were limitations of the Treaty of Versailles interrupted the military tradition. The performance of the newly developed aircraft, tanks, submarines, and antiaircraft guns was spectacular in the first part of the war.

The first big war successes were a clear demonstration of the value of technical superiority, but they produced an odd reaction. In the summer of 1940, war-material production and development was cut down severely; in particular, aircraft development was almost completely halted, mainly because the military and political leaders disliked to see most of the credit for the successes go to the technical side. It took a long time and the convincing argument of many defeats before a revision of the policy was undertaken—too late to make it effective.

Throughout the war, the German armed forces had almost unlimited power to draft everybody, however necessary their work might be. The number of deferments for engineers and scientists was ridiculously small, and every job had to be covered continuously by urgency degrees. Apart from the direct loss in valuable man power, a great deal of indirect damage was done through this indiscriminate drafting policy. Many engineers dared not use their sound judgment with respect to the work they did for fear of killing the urgency degree that protected their job. A revision of the scientific man-power policy came later in the war. When the military situation looked more and more desperate, even the military leaders were able to see that an infantry division more or less, could not improve their chances but that a few new weapons might still do it.

Relatively little damage was done to the armament production and development by the air raids, primarily because the factories and laboratories were extremely well equipped and had to work far below their capacity and because they were widely decentralized.

In the field of aircraft development, industry-wide cooperation functioned on a much higher plane. The factories that survived the competition during the depression were, in general, managed by engineers, and the relations between leading firms were good. New developments were freely discussed within security regulations, Mr. Multhopp pointed out. While research institutes were satisfied to run routine wind-tunnel tests on aircraft prototypes, the industry felt better served by basic research. Hence, a committee representing the industry met regularly to revise the research policy, with excellent results. Mr. Multhopp's conclusion to this survey was the following: "In spite of often brilliant technical solutions and excellent equipment of all factories, there was no coordination of the military necessities and technical possibilities. In wartime, it is not enough to have a high technical standard in a country; one really has to use it and to improve it continuously at the highest possible rate."

Boston Section

L. J. Nuttall, *Secretary*

Joseph Bicknell, Professor of Aeronautics, Massachusetts Institute of Technology, addressed the members at the March 21 meeting held at M.I.T. The subject was "The New Transonic Wind Tunnel at M.I.T."

Professor Bicknell told the group about the problems that had to be over-

Student-Paper Contest Winner: *Student Member Angelo Borzachillo (left) of The Aeronautical University, Inc., is congratulated by Chicago Section Chairman K. L. Burroughs. Mr. Borzachillo was the winner of the Student-Paper Contest sponsored by the Chicago Section (q. v.).*

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. . . for PISTON, JET and TURBO JET ENGINES

Bendix experience extends to every phase of aircraft propulsion. For more than twenty-five years problems of ignition for every type of aircraft engine and operating condition have found their solution in the resources and skill of Bendix. That's why the aviation industry has come to consider Bendix the one source *uniquely qualified* to design and produce ignition equipment to meet every operating requirement.

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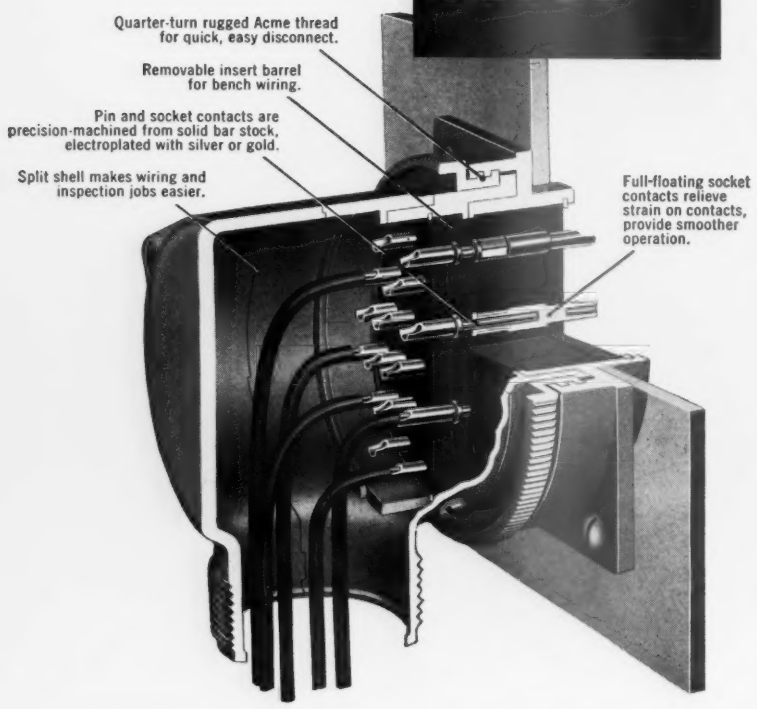
Quarter-turn rugged Acme thread for quick, easy disconnect.
Removable insert barrel for bench wiring.
Pin and socket contacts are precision-machined from solid bar stock, electroplated with silver or gold.
Split shell makes wiring and inspection jobs easier.
Full-floating socket contacts relieve strain on contacts, provide smoother operation.

Recognition of Cannon's 36 years of sound engineering and fine, uncompromising construction has built the demand for Cannon Plugs. Here we take an inside look at the lightweight Type "K" 90° connector, forerunner of the Army-Navy Series. More features of the "K" were incorporated into the "AN" design than any other connector.

Constantly improved over the years, Type "K" is now used for numerous applications such as aircraft, radio, television, sound, phone recorders, motion pictures, geophysical research and widely used throughout the electro-mechanical and electronic instrument fields.

The design and construction details in the Cannon "K" Series are typical of the care Cannon takes in producing more than 18,000 precision, multi-contact connectors to serve the exacting needs of industry.

We will gladly send you engineering bulletins describing each of the many basic types of Cannon Plugs if you will briefly describe your applications.

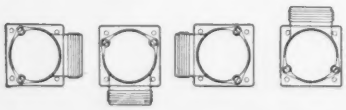

Diagram at left shows how the four positions of cable entry on the large 90° "K" endbell make the wiring job easier. Smaller Type "K" connectors have three positions.

CANNON ELECTRIC

Since 1915

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Type "K" and "RK" connectors are available in 7 shell types having 8 diameters. Inserts have more than 190 contact arrangements. Some of these have Coax, Twinax or Thermocouple contacts as standard. Integral cable clamps available in all "K" plug types.

Factories in Los Angeles, Toronto, New Haven. Representatives in principal cities. Address inquiries to Cannon Electric Company, Department. F-105, P. O. Box 75, Lincoln Heights Station, Los Angeles 31, California

come in building a wind tunnel and went into details on the design and operational features of it. The tunnel was designed for intermittent flow for Mach Numbers from 0.8 to 1.3. A complete run took only 15 sec., which made the instrumentation problem rather acute. Only one run an hour could be made, however, since it took that long to fill the pressure chamber. One of the major problems encountered was maintaining a constant air temperature at the test section. This was overcome by installing a large temperature stabilizer with 22,000 sq.ft. of heat-transfer surface at the discharge from the pressure chamber.

The primary use of the wind tunnel will be for studying aeroelastic problems of airplane structures in the transonic region, rather than for aerodynamic research, although boundary-layer and shock-wave effects will also be studied.

Attendance at this meeting was the best of the year, and all present were impressed with Professor Bicknell's talk.

Chicago Section

Alfred F. Stott, *Secretary*

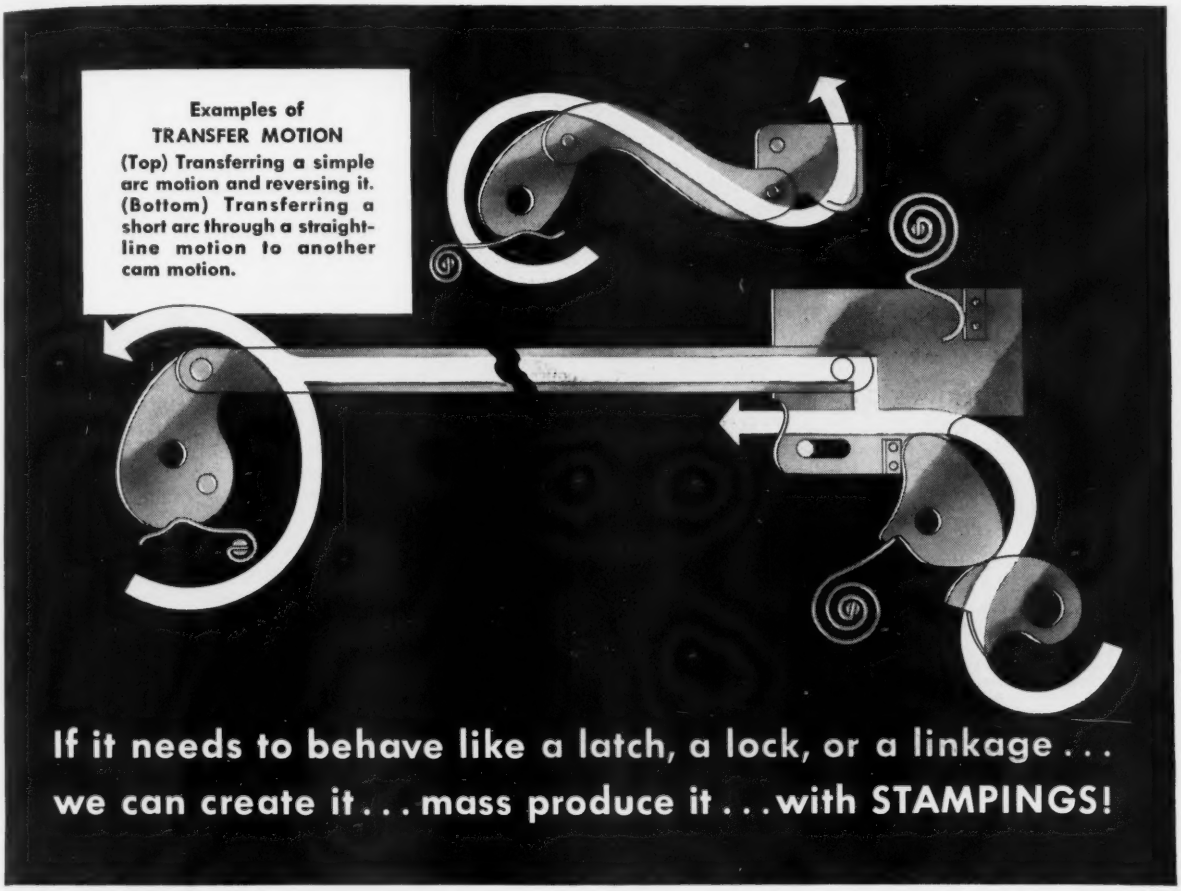
On March 29, 27 members met at the Illinois Institute of Technology for dinner at 6:30 p.m.

The meeting was called to order by Section Chairman K. L. Burroughs at 8:00 p.m. Thirty-nine members were present. The meeting was to honor the Student Branches in this area by holding a student-paper competition. The six Student Branches—namely, Illinois Institute of Technology, University of Illinois (Navy Pier, Chicago), University of Illinois (Urbana), Purdue University, Notre Dame University, and Aeronautical University—were invited to compete, but only two were able to send a participant.

Thomas Dolan, Illinois Institute of Technology, presented a fine paper on "The Possibilities of Interplanetary Travel." Angelo Borzachillo, Aeronautical University, spoke on the "Design of Ram-Jets." The judges of the contest were Prof. Richard Hartenberg, of Northwestern; Capt. Wallace Mechling, of Naval Air Station, Glenview; and Charles Bonnette, of Globe Corporation's Aircraft Division. The competition was extremely close, with the decision going to Mr. Borzachillo. Mr. Burroughs presented the winner with a check for $25 and an inscribed gold trophy. Mr. Dolan was given a check for $10.

Dr. Harold Hawkins, Past-Chairman, spoke briefly on the work of the I.A.S. Council and told of his attendance at the Council meetings.

Chairman Burroughs outlined plans for the April 17 meeting, which is a


Examples of
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(Top) Transferring a simple arc motion and reversing it.
(Bottom) Transferring a short arc through a straight-line motion to another cam motion.

If it needs to behave like a latch, a lock, or a linkage . . .
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Keep your product in mind as you check through these types of "Motions" made by Standard. They include devices to: spring open or shut a lid . . . start or stop a machine . . . lock or latch a door . . . raise or lower a panel . . . initiate or check a movement . . . position or control a force.

In this list may be a "Motion" which is required in *your* product. If so, remember that Standard Products engineers are full-time specialists in designing sure-acting motions that *exactly* fit the needs of the job to be done. Furthermore, by employing modern mass-production and assembly techniques, we can make motion-devices with *stampings* . . . to keep the cost unusually low.

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A steel Rosán Insert, screwed into magnesium or aluminum alloys and locked in with the Rosán Ring, will withstand greater loads than the fastening bolt used to join the two sections to be held.

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Once the studs are locked in the parent material, there is no chance of vibrating loose, and even a frozen nut may be easily removed with no question of the stud turning or becoming loose.

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The many teeth of the Rosán serated locking ring give the immense bearing surfaces required for secure fastening. The inner circle of serations holds the insert or base of stud—the outer circle, when driven into position, becomes an integral part of the parent material.

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joint meeting with A.S.M.E., and the May meeting at the Naval Air Station, at which time new officers will be elected. The meeting was closed at 9:45 p.m.

Dayton Section

W. A. Barden, *Secretary*

On February 27, Col. L. C. Moon, Chief, Test Engineering Subdivision, Flight Test Division, addressed the members and guests of the Dayton Section on "Test Engineering Techniques." In the course of his talk, Colonel Moon remarked about some peculiar behavior of various instruments under supersonic flight conditions. Colonel Moon's talk was supplemented by a motion picture titled *Profile of a Test Pilot* and by an extensive display of instruments and equipment used in flight testing. All present showed exceptional interest in the talk and the displayed equipment.

Hagerstown Section

Robert A. Darby, *Secretary*

The March 20 meeting was held at the Hotel McLaughlin, Greencastle, Pa. Section Chairman Robert D. Gilson presided. Walter Tydon introduced the speaker of the evening, Randall C. Smith, Assistant Chief Engineer, East Coast Aeronautics, Inc.

Mr. Smith presented a paper entitled "The Application of Magnesium in Aircraft Structures," which had been prepared by J. P. Donald Garges, Chief Engineer, East Coast Aeronautics. Mr. Smith elaborated generously upon the original paper and bore up admirably under a long question period. The paper centered about several all-magnesium versions of wings that East Coast Aeronautics has produced for service aircraft—notably the F9F and T-6. The reduction in the overall number of parts and in the number of fasteners in the magnesium wings, as compared with the aluminum wings, is striking. Strength, stiffness, and fatigue characteristics of the magnesium wings are excellent. Mr. Smith went to particular pains to discuss forming processes and the connection of magnesium members to fittings of other material, such as steel wing-hinge fittings.

Los Angeles Section

Milton A. Miner, *Secretary*

On February 1, Dr. A. T. Zahorski, Supervisor, Dynamic Analysis, Northrop Aircraft, Inc., spoke before a specialists' meeting on "Remarks on Dynamic Loads in Landing." Dr. Zahorski offered a new and simplified, yet rigor-

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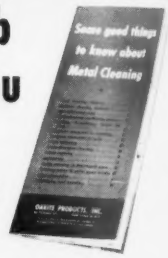

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ous, approach to the analysis of the dynamic loads in landing. His analysis is easily applied to arbitrary force functions and gives the criteria under which predicted dynamic loads may be considerably magnified or diminished. He established working limits to the number of modes of vibration which are effective in contributing to the results that may be obtained in a given problem. Walter Hurty, member, Program Committee, presided.

▸ On February 15, Dr. Lee A. DuBridge, President, California Institute of Technology, spoke at the dinner meeting on the subject, "The Emergency Manpower Problem." Presiding was Holley B. Dickinson, member, Program Committee.

As a member of the Scientific Manpower Committee, National Security Resources Board, Dr. DuBridge was able to give a detailed discussion of the findings of the Committee on the all-important problem of man power with particular reference to scientific and technical personnel.

He reported that the members of this Committee, who represent various elements of American industry and educational institutions, found that the minimum overall man-power requirements for adequate National Defense required that 18-year-old men be drafted. To meet the current planned military needs, the period of service must be 27 months. It was proposed that all men serve a 6-month basic-training period shortly after they reached the age of 18. During this period, various means of selection would be used to channel these youths into one of the following programs: (a) military service; (b) officer-candidate training schools; or (c) colleges or universities for technical, medical, or other specialized training. Men completing the training under this latter program would then be subject to assignment by the Scientific Manpower Committee in order that the overall defense program could be provided with requisite man power if this became necessary.

▸ A meeting of the Historical Associates was held February 16 at 8:00 p.m. in the I.A.S. building. The address by Roy Knabenshue commemorated the forty-first anniversary of the Dominquez Air Meet. The speaker has had a wide acquaintance with many of the early pioneer aviators, such as Glenn Curtiss, the Wright brothers, Capt. Thomas Baldwin, and Lincoln Beachey. In his talk, Mr. Knabenshue described his early dirigible flying and the building of his own balloons and structures, engines, and propellers.

▸ A joint meeting with the A.S.M.E. was held on February 22 on the subject, "Scientific Approach to Plant Layout." The speaker was N. A. Lamberti, Head, Methods and Standards Department,

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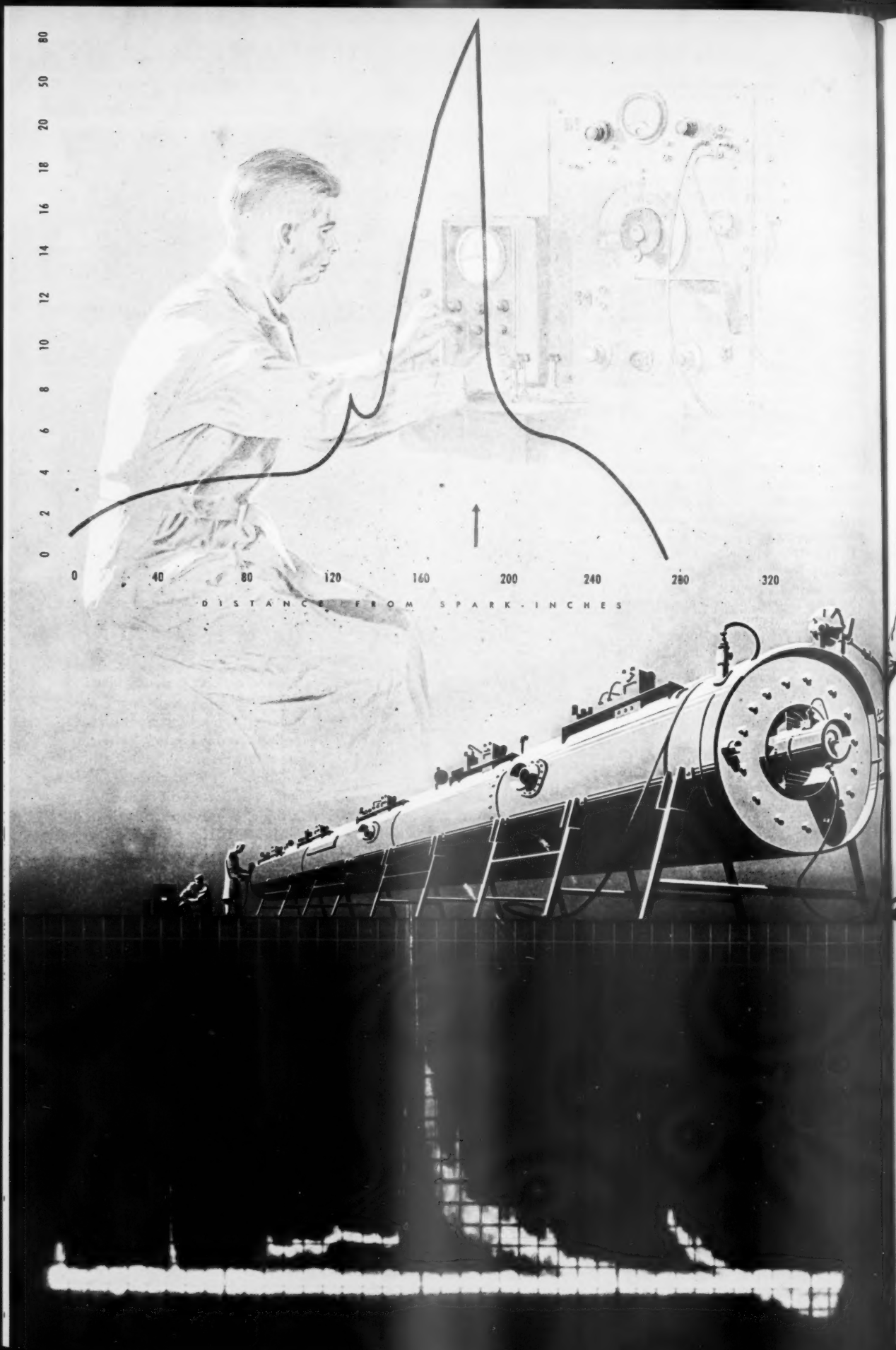
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GROWTH OF A FLAME

What really happens when a flame front accelerates to seven times the speed of sound? No one knows the whole story. But the real nature of these combustion phenomena is being unfolded in a fundamental research program sponsored by the American Gas Association, and conducted at the Toledo laboratories of Surface Combustion Corporation. Already this project has provided some fascinating new concepts of flame propagation behavior.

Much is known about "slow speed" flame propagation, and about detonation. However, efforts to measure the speed of a flame racing through the transition zone have thus far been unsuccessful. A new technique and new test equipment were devised by Surface Combustion: a 70-foot tube lined with ionization and pressure sensitive devices to provide hundreds of oscillographs from which "flash pictures" of flame acceleration could be drawn. The chart at the upper left, for example, pictures for the first time the conditions under which a flame front begins to gather supersonic speed and overtake the pressure wave preceding it. From these data may come fundamental knowledge contributing to a general theory of combustion.

What does such research mean to the aircraft industry . . . and all other industries concerned with combustion? As in any fundamental research, practical applications may not come about immediately. However, it is basic research of this kind that has provided a firm foundation for the entire array of Surface Combustion industrial products ranging from complete fuel gas production plants and massive steel mill soaking pits to kilns for decorating the finest chinaware. The same basic research and experience is behind the design, construction, and performance of Janitrol aircraft heaters and combustion equipment. Your nearest Janitrol representative is always at your service.

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McCulloch Motors. R. R. Heppe, Vice-Chairman of the Program Committee, presided. Mr. Lamberti pointed out that plant layout is one of the most important problems in the field of Industrial Engineering. It deals with the arrangement of the physical facilities and man power required to manufacture a product. The overall objective is to plan the arrangement of facilities and personnel so that the manufacturing process is carried out in as effective a manner as possible. This objective involves a minimum of movement on the part of materials and personnel and a minimum of time in process for any individual part. Plant layout may be defined as planning the path each component part of a product is to follow through the plant, coordinating the paths of the various parts so that the manufacturing processes may be carried out in the most practical and economical manner, preparing a scale drawing or other representation of the arrangement, and, finally, seeing that the plan is put into effect properly.

Montreal Section

G. E. Otter, *Secretary*

The March 29 meeting was held in the Mount Royal Hotel. William I. Stieglitz, Design Safety Engineer, Republic Aviation Corporation, addressed the meeting on the subject, "Cockpit Design for Safety." He was graduated from Massachusetts Institute of Technology in 1932. At one time, he was Chief of Aerodynamics and Flight Test, Fleetwings Division, Kaiser Cargo, and, since 1944, has been with Republic as Design Safety Engineer.

Mr. Steiglitz presented in a forceful manner many new ideas and drew attention to the importance of adhering to the highest standard in safety in some of the well-known, but often overlooked, design features. He pointed out that during the past 30 years airplanes have increased greatly in complexity, speeds have increased from 100 to over 600 m.p.h., and landing speeds have increased as have the duties of the pilot. The pilot's time to perform his duties has been reduced, but the man himself has remained with the same limitations; his reaction and reaction time have not changed.

Mr. Steiglitz charged that the doctors were not doing so good a job in improving man as the engineer was in improving the airplane. Therefore, the engineer must take cognizance of man's limitations and provide every possible device and simplification to relieve the pilot.

Mr. Steiglitz pleaded for standardization of cockpits. Any good arrangement of the 47,000 possible combinations would be acceptable. Valuable time is being lost while the optimum arrangement is being sought. Since the pilot's reactions become automatic, the pilot controls the airplane similar to the way his nervous system controls his body; therefore, it is essential in the interest of safety that all cockpits be standardized. A discussion period followed the talk.

Philadelphia Section

Dale Hamilton, *Secretary*

Floyd H. Bair, from the Naval Air Experimental Station, Philadelphia, discussed the application of metal adhesives to aircraft construction at the March 7 meeting. He was introduced by C. W. Lefever.

Mr. Bair reviewed the two basic types of adhesives: the rubbers and the phenyls. The characteristics can be varied from elastic to hard and brittle. The strength characteristic fairly well follows the hardness.

Metal adhesives are being used for a large number of applications in aircraft, including nonstructural items (such as doors) and structural items (such as wing panels and tail surfaces). The main advantages of metal adhesives are: (1) more uniform load distribution; (2) weight-saving; (3) structural rigidity; (4) aerodynamically smooth surfaces; (5) more usable internal space; (6) pressure tight joints; (7) cost-saving; (8) combination forming and gluing possibility; (9) longer service life and lower maintenance cost; and (10) noise reduction. The disadvantages are: (1) no good nondestructive method of determining the quality of the joint; (2) careful process control required; (3) a failure is a total failure; (4) low peal strength, requiring mechanical fastener at ends of joints; (5) loss of strength at elevated temperatures; and (6) special design requirements.

A typical example of the special design requirements is the lap joint. The stresses in the adhesive at the edge of the sheet are high. The strength of a lap joint increases proportionally to the width of lap for about 0.5 in.; from 0.5 to 1 in., there is some further increase. There is little or no increase in strength for lap joints of over about 1-in. lap.

A discussion period followed the interesting talk given by Mr. Bair.

Pittsburgh Section

R. H. Fields, *Secretary*

At the March 7 meeting, J. P. Donald Garges, Chief Engineer, East Coast Aeronautics, Inc., spoke on "The Application of Magnesium in Aircraft Structures."

Recent developments in aircraft design and performance have given the structural designer additional tasks, those of keeping the structural weight down and of increasing torsional and bending rigidity in thin sweptback wings—a problem that is further aggravated by aerodynamic heating. The speaker's company, working under Air Force contract, designed a thick-skinned magnesium wing for the F-80. This resulted in an increase of compressive buckling strength and rigidity by putting the material where it was most needed. Several advantages were hereby realized: the number of parts was reduced by 69 per cent; dimpling was no longer necessary as the skin was thick enough to countersink; design calculations were reduced; man-hours in construction were reduced; aerodynamics was improved by the smooth wrinkle-free surface of the wing even under design load; and increased fuel capacity due to the extra space was made available by the elimination of longerons and stiffeners.

The same type of wing was designed for the Grumman F9F. Presently, a number of sets of these wings are being service tested by carrier-based aircraft. It should be noted that, while there was no reduction in weight of the magnesium wing over the aluminum, there was a substantial increase in torsional and bending rigidity of the wings. Mr. Garges also pointed out that with finishes now available magnesium does not present any more corrosion problems than aluminum.

San Diego Section

W. H. Shutts, *Secretary*

On March 29, an interesting talk on "Current Developments in Helicopter Design and Operation" was presented by C. Langhorne Washburn, Assistant to the President, Hiller Helicopters, at a joint meeting of the San Diego sections of the I.A.S. and the S.A.E. The dinner meeting was attended by 166 members and guests of the organizations.

Mr. Washburn has been associated with the Hiller organization since 1946, first as Operations Manager and later as Assistant to the President. He is a helicopter pilot in his own right and has many hours logged to his credit.

The talk was primarily concerned with the evolution and development of the two-passenger "Hiller Hornet," which is powered by two tip-mounted ram-jet power plants developed by Hiller. The Hornet has only two hand controls, and it has fewer instruments on its panel than the average automobile. Mr. Washburn stated that the entire disassembly of the twin-jet engines may be accomplished in a matter of minutes with no other tool than a screw driver.

Basically, the craft consists of a combination aluminum and steel tubular

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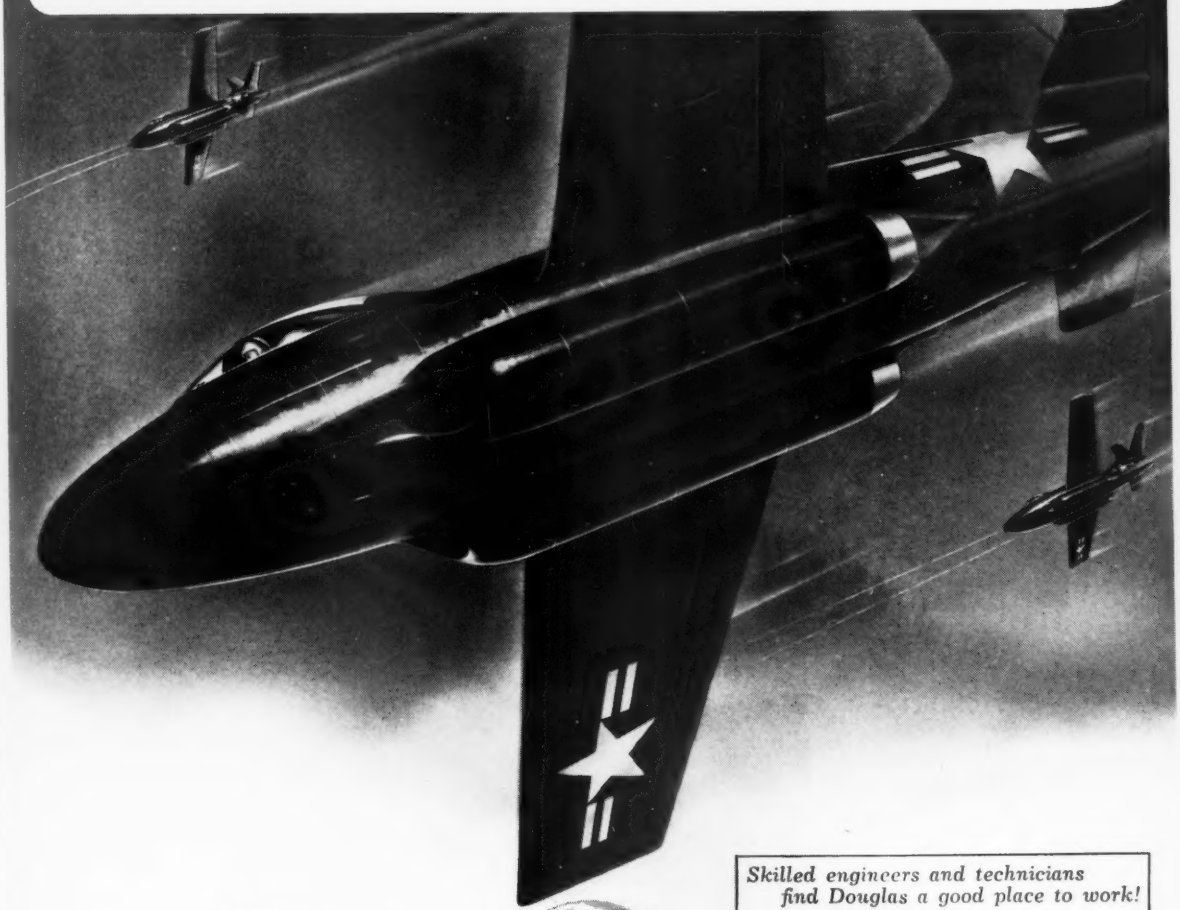

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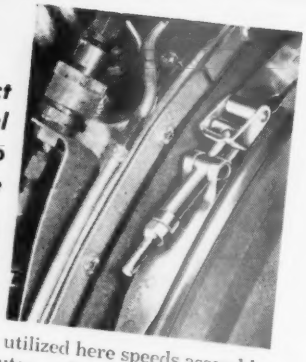

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Other interesting facts that Mr. Washburn brought out about the Hiller Hornet are: weight per jet engine is 11 lbs.; thrust per engine equals 31 lbs.; power-off rate of descent is about 2,200 ft. per min. but by proper pitch control may be "flared" just above the ground to provide almost zero landing speed; predicted ceiling is roughly 12,000 ft.; cruising range is more than 50 miles; and cruising speed is in excess of 75 m.p.h.

Motion pictures of the Hiller Hornet in flight illustrated the extreme simplicity of controls and the maneuverability of this craft.

The talk was followed by an interesting question-and-answer period.

Texas Section

R. Christy, *Secretary*

The March 26 meeting was held at the American Legion Hall, Grand Prairie, Tex. The meeting was opened by M. E. Kurzawa, Chairman, who then discussed the membership drive and reported on the activity of the Membership Committee. Harold Johnson was called upon to report on the procedure for obtaining the necessary clearance for a closed meeting to be held April 25.

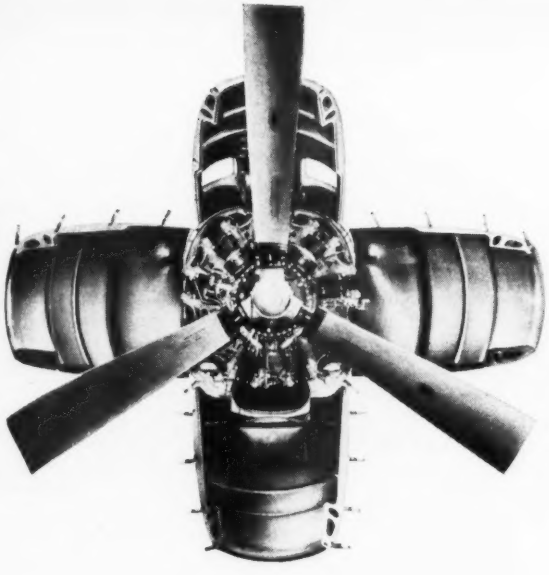
Howard Marx introduced C. L. Seacord, who spoke on "The Use of Rocket Propelled Models for Aerodynamic Research." Mr. Seacord is presently assigned to research on dynamic stability and servomechanisms with Convair. He was previously associated with the N.A.C.A. as a dynamic stability specialist assigned to test projects in a free-flight tunnel and later to dynamic stability research on the MX570, the first subsonic missile.

Mr. Seacord discussed the advantages and disadvantages of testing free-flight models to obtain aerodynamic data, the types of models and instrumentation used, and the reliability of the data obtained.

Toronto Section

S. L. Britton, *Secretary*

The guest speaker at the March 7 meeting was Mr. Smallman-Tew, Chief Metallurgist, Aircraft Division, A. V. Roe Canada Limited, who was introduced by Chairman H. C. Luttman.



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Mr. Smallman-Tew has been connected with the aircraft industry for 10 of his 23 years in the metallurgical field; in the war years, he was one of a team of experts sent by the M.A.P. to study spot-welding techniques in the U.S.A.

His subject, dealing with the future of magnesium in the Canadian aircraft industry, outlined the rise of magnesium from an aura of suspicion, caused by ignorance, to a point where it supplements and in many cases supplants strategic materials. Although Canada produces the purest form of commercial magnesium, the lack of refining and rolling facilities necessitates the utilization of American factories with the attendant complications of customs clearance and tariff payments.

The weight-saving and resultant increase of revenue for air-line operators by the use of magnesium was illustrated by reference to the Avro Jetliner. Comparisons with steel and aluminum alloys show that, although on a cost-per-unit weight basis magnesium appears unfavorable, the cost per unit volume is extremely favorable. Hence, a larger volume and, consequently, a stiffer structure can be provided for the same cost.

The problems of forming in magnesium were discussed, and it was pointed out that, given the proper equipment, magnesium possesses excellent properties for deep drawing and forming. However, the need for improved techniques was stressed. The speaker strongly recommended the establishment of facilities in Canada for the complete processing of magnesium from the ore to the finished product.

The speaker was thanked by Carl Lindow, Past Chairman, for his most topical paper. Mr. Lindow re-emphasized the need for a new approach by Canadian manufacturers to the many uses of magnesium.

Washington Section

C. D. Auld, *Secretary*

The January 9 meeting was sponsored by the Office of Naval Research. Dr. Allan Q. Waterman, Deputy Chief of Naval Research and Chief Scientist, Office of Naval Research, spoke on the role of O.N.R. in supporting and sponsoring research in the aeronautical sciences. Dr. Waterman presented a picture of the manner in which the activities of O.N.R. are concerned with research, development, and production as related to the biological, natural, and naval sciences. He emphasized the concern of O.N.R. in diminishing the time lag between the results of basic research and the application of such results to production of a useable article.

I. R. Kramer, Head, Metallurgy Branch, Natural Sciences Division, discussed the present status of some of the newer metals as applied to air-frame and engine construction. He pointed out the difficulty in predicting the behavior of metals in actual service from results of laboratory tests. Effort is being directed toward obtaining a better understanding of the behavior of metals in order to reduce the tremendous safety factor required in air-frame design at present. Mr. Kramer closed his address with a discussion of the attractions and limitations of some of the newer metals (titanium, molybdenum, etc.) and their possible future applications.

Commander R. L. Christy, Jr., Flight Surgeon, who has been guiding programs in aviation medical research for many years, spoke on "Life in Aircraft." Dr. Christy outlined the problems encountered in investigating the effects of flight in modern military aircraft on pilots and flight crews. He discussed the effects of altitude operation, high-speed flight and maneuvering, and complexity of instrumentation on the efficiency of flight personnel. He stressed the desirability of instrumentation of the "all is well or not well" type whenever possible, rather than instrumentation that requires remembering warning readings, etc. Dr. Christy closed his talk with a discussion of the efforts being made to secure personnel safety in crashes and high-speed bail-outs.

The last speaker, Major D. B. Blue, U.S.M.C., presented his observations of the status of recent aeronautical research on the European continent. Major Blue had recently returned from a tour of various aeronautical establishments in Germany, France, Italy, and Switzerland. Of particular interest was his discussion of work being done in Germany on the problems of boundary-layer control. Several successful flights have been made, and the problems of application of boundary-layer control to obtain practical operational aircraft are much closer to being solved than is generally realized in this country.

Wichita Section

Melvin H. Snyder, Jr., *Secretary*

The April 5 meeting was devoted to discussions of high-speed flight. Two analyses of speed and predictions of things to come were presented by Dean Kenneth Razak, Director, School of Engineering, and Dean, College of Business Administration, University of Wichita, and by Prof. Melvin H. Snyder, Jr., Head, Aeronautical Engineering Department, University of Wichita.

Dean Razak presented a paper authored by Dr. Theodore von Kármán and G. Gabrielli entitled "What Price Speed." This paper analyzed the cost of speed by comparing all sorts of vehicles in terms of their specific power and specific tractive force. A limiting condition was found for all vehicles (from horses and motorcycles to ocean liners and jet planes). Two new parameters that serve as limits were found. These parameters involved the static rupture length of materials and the dynamic rupture stress. It was predicted that the use of titanium as structural material will make possible higher speeds with the same power loading and specific tractive force.

Professor Snyder reviewed "Predictions of Supersonic Airplane Performance" by Harold Luskin. This paper was published in the January, 1950, issue of the JOURNAL OF THE AERONAUTICAL SCIENCES and points out the general type of time growth curve of airplane speeds and the fact that recent developments and the radical change in the type of propulsive system are resulting in a new segment of the growth curve. Supersonic performance limitations are discussed, and the necessity for increased wing loading in supersonic aircraft is pointed out. Mr. Luskin stated in this abstract that ". . . increases in speed and improvements in the safety record have been obtained simultaneously, in spite of increasing wing loadings. This trend is expected to continue."

Chairman Douglas C. Heimburger announced that the I.A.S. National Personal Plane Meeting usually held in Wichita would not be held this year. Plans were made for a regional personal plane meeting entitled "Personal Plane Report—1951." [This meeting, held in Wichita on May 3, 1951, featured reports from industry, executive plane operators, airport operators, and Army Ground Forces.]

Changes of Address

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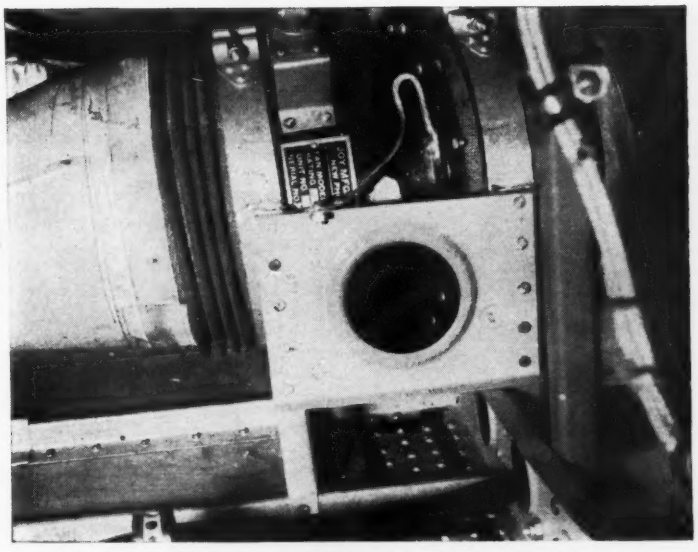

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Student Branches

Academy of Aeronautics

A slate of officers for the new term was elected on February 19 with the following results: Chairman, Bernard Buc; Vice-Chairman, Edward Rode; Secretary, Warren Baur; Corresponding Secretary, Calvin Holbert; and Treasurer, Frank Negro. Student Members Louis Popovich and Richard Schunk presented papers on the "Formation of Ice on Aircraft" and "Satellites Around the Earth," respectively. Mr. Schunk was voted the I.A.S. award winner for the most interesting speech based on delivery, poise, and subject matter. Chairman James Sneden presided over the election of officers and introduced the student speakers; 19 persons attended.

The Aeronautical University, Inc.

An election of officers took place on February 15 with the following results: Chairman, Woody Kokita; Vice-Chairman, Eugene A. Czeck; Secretary, John F. Jeglia; and Treasurer, Stanley M. Kilcher. Carl C. Norman was elected Honorary Chairman. Secretary Woody Kokita conducted the meeting at which 29 persons were present.

The officers-elect were installed at the March 8 meeting. Chairman Kokita presided; 26 students were present.

On March 15, Student Member Angelo Borzachillo presented an oral summary of his written paper on "Subsonic Ram-Jet Design," which had been prepared to represent the Aeronautical University in the I.A.S. Student Paper Contest conducted by the Chicago Section. [This paper later won the contest at the March 29 Chicago Section meeting.]

University of Alabama

Student Branch Chairman, Major Mortimer D. Marks, U.S.A.F., presided at the March 13 meeting at which 25 persons were present. The speaker was Col. Henry Warden, U.S.A.F., Air University, Maxwell Air Force Base, Ala., who lectured on "Fighters, Bombers, and the Aeronautical Engineer."

On March 27, Dr. Marcus Whitman, Professor at Alabama, lectured on "Transports in Commercial Aviation." Major Marks presided; 22 persons were in attendance.

Cal-Aero Technical Institute

One hundred persons attended the address on I.A.S. student membership given by Student Branch Secretary, Charles Reid, on February 1. Two films, *Wing Structures* and *Static Testing*, were shown. Chairman William Lee presided.

University of Cincinnati

The March and April meetings were given over to talks by seniors competing for an I.A.S. prize. John Martz spoke on "The Stability of Free-Flight Aircraft," and Oscar Dillon presented a talk on "Rocket Propulsion." Several movies, including *The Rise and Fall of Nazi Germany*, were shown.

Clarkson College of Technology

On March 8, Nathaniel T. Bartholomaei, Instructor, Mechanical Engineering, Clarkson, spoke on "Aircraft Engine Testing." Following this lecture, two films, *Night Vision for Airman* and *Acrobatics*, were shown.

University of Colorado

Professor Durham, Aeronautical Department, University of Colorado, was the speaker of the evening at the January 30 meeting. His subject was "The Experimental Department of Pratt & Whitney." Chairman Myron J. Miller led the meeting; 22 persons were present.

"Problems of Jet Engines in Commercial Aircraft" was the subject of Ray Kelly's illustrated lecture at the February 8 meeting. Mr. Kelly is Superintendent of Technical Development, United Air Lines, Inc. Chairman Miller presided; 23 persons were in attendance.

The February 20 meeting was called to order by Chairman Miller; 20 persons were present. The "National I.A.S. Convention" was the topic of the lecture presented by Prof. K. D. Wood, Head of the Aeronautical Department.

The annual banquet was held on February 23 with an attendance of 51 persons at the Aviation Country Club, Denver. After-dinner speakers were Dean Clarence Eckel, Dean of the Engineering School, and Professor Wood. Dancing concluded the evening's entertainment.

University of Detroit

On March 29, Dr. Ross, an Instructor in the Aeronautical Department, gave an illustrated discussion of the "Water Table Phenomena." Chairman Donald R. Lapworth led the meeting; 15 persons were present.

University of Florida

Chairman Costa Francisco opened the March 6 meeting at which H. W. Trammel, Service Engineer with the C.A.A.'s Atlanta Regional Office, spoke on the "Functions of the C.A.A." The showing of a C.A.A. film entitled *Safe Aircraft* followed the talk. Twenty-five persons were present.

Iowa State College

On January 19, James E. McDonald of the Physics Department lectured on the "Aerodynamics of a Raindrop." A motion picture, *Fortress in the Sky*, was shown.

At the February 21 meeting, Norbert Locke, Chairman, Iowa Aeronautical Commission, spoke on the Commission and recent happenings in the aviation world.

The March 9 meeting was called to order by Vice-Chairman Glenn Minott. Carl N. Sanford, Aeronautical Department Head and Honorary Chairman, spoke on I.A.S. membership.

An election of officers was held on March 28 with the following results: Chairman, Eugene Dandy; Vice-Chairman, Lawrence Prestjohn; and Secretary-Treasurer, Duane Schoelerman. Vice-Chairman Glenn Minott had opened the meeting. The new officers took their positions at this meeting.

University of Illinois

Two films, *Ground Controlled Approach* and *Survival in the Arctic*, were shown at the April 4 meeting. Chairman Corliss Laisure presided and 22 persons were present.

University of Maryland

A new Student Branch was formed here on March 7 with Robert M. Rivello, Assistant Professor, as Faculty Adviser. The following students were elected to office by the 24 attending members: Chairman, William S. Bissell; Vice-Chairman, Herbert C. Spicer; and Secretary-Treasurer, Ruben M. Gloria.

Massachusetts Institute of Technology

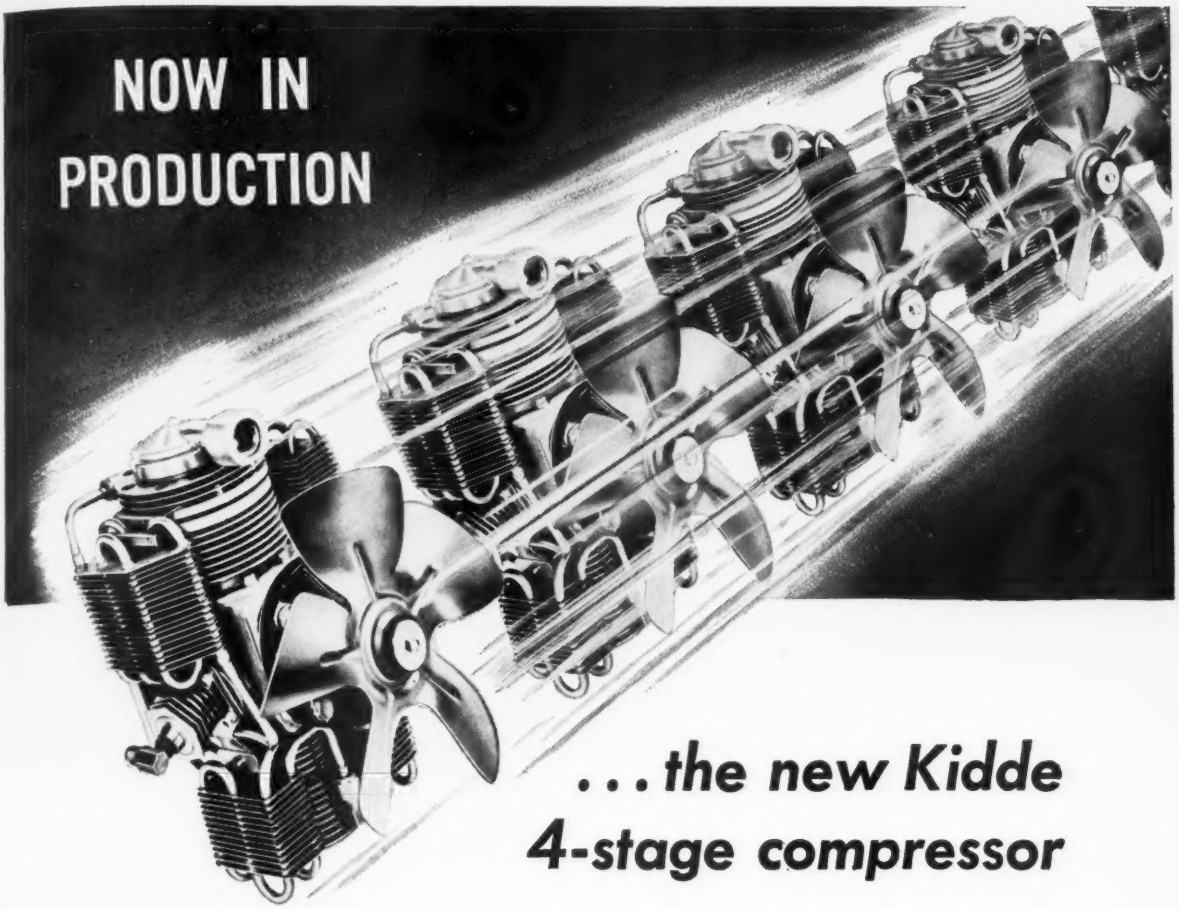
John R. Markham, Professor of Aeronautical Engineering, M.I.T., lectured on "Supersonics" at the February 27 meeting. Chairman Henry R. Jex presided; 31 persons were present.

On March 19, a film entitled *Aeronautical Oddities* was shown. Chairman Jex presided and 36 were in attendance.

Northrop Aeronautical Institute

A film, *The C-124 Globemaster*, was shown at the March 21 meeting. Chairman J. C. Chaffee presided and 53 persons attended.

At the March 22 meeting, Dr. A. L. Klein lectured on the general economics



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of aircraft design. Dr. Klein is Design Consultant, Douglas Aircraft Company, Inc.; Associate Professor, California Institute of Technology; Technical Consultant, Cooperative Wind Tunnel; and Supervisor, Instrumentation and Equipment Design, Guggenheim Aeronautical Laboratory. Chairman Chaffee led the meeting; 125 persons were present.

Riddle McKay College of Aeronautics

On March 14, 18 persons gathered to vote for a new secretary. Robert J. Boyne was duly elected. Chairman Robert E. Frazer led the meeting.

An Alcoa film, *Curiosity Shop*, was shown in the I.A.S. Theatre on March 22. Chairman Frazer conducted the meeting; 42 persons were present.

Spartan College of Aeronautical Engineering

At the April 3 meeting, Earl E. Mohr and Robert Leo Crawshaw were elected to the positions of Secretary and Corresponding Secretary, respectively.

Stanford University

Officers for 1951 are as follows: Chairman, James Lee Taylor; Vice-Chairman, Ralph W. Franks; and Secretary-Treasurer, John A. Thelander.

Tri-State College

The following officers were inducted at the March 29 meeting: Chairman, Ben K. Gantt; Vice-Chairman, Jack Jewell; Secretary, Kenneth S. Woodard; and Treasurer, Joseph Bligh. The film, *Tornado in a Box*, was shown. Sixteen persons were present.

University of Virginia

Officers elected for 1951 are: Chairman, William H. Kindell; Vice-Chairman, Robert D. Powell; Secretary, Robert H. Kirby; and Treasurer, Robert A. Brown. The Faculty Adviser is Asst. Prof. James E. May.

University of Washington

On March 1, P. Heasley Entz, Structures Engineer, Design Loads and Stress Unit, Boeing Airplane Company, spoke on the "Effects of Aeroelasticity on Aerodynamics and Stability." Chairman John R. Gintz presided; 26 persons attended.

Twenty persons gathered on March 7 to see the showing of a motion picture, *Science in Photography*. Chairman Gintz presided.

Wayne University

Twenty students met on March 21 to hear C. C. La Vene, of Douglas Aircraft Company, Inc., speak on "Jobs and Opportunities at Douglas." This was followed by the showing of three films: *Air Oddities*, *Your Air Force in Action*, and *How Not To Run a Meeting*. Chairman Ronald Barcus presided.

West Virginia University

The Officers for the Second Semester were announced at the March 7 meeting as follows: Chairman, Sam Hill; Vice-Chairman, Gene Fourney; Secretary-Treasurer, Mr. Carpenter; and Corresponding Secretary, Malcolm Ullock. Two films, *Aerodynamics* and *Bomber*, were shown. Chairman Hill presided; 14 persons attended.

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Elected to Associate Fellow Grade

Soule, Hartley A., B.S. in M.E., Asst. Chief of Research, N.A.C.A., (Langley Air Force Base).

Elected to MEMBER Grade

Allen, Charles F., B. of Ae.E. Liaison Engineer "A," Northrop Aircraft, Inc.

Botstiber, Dietrich W., Dipl. Ing., Chief, Mech. Development, Piasecki Helicopter Corp.

Branahl, Erwin F., B.S.C.E., Design Engineer, in Charge of the Dynamic Analysis Group, McDonnell Aircraft Corp.

Carhart, Nathan A., Design Co-ordinator, Engineering Dept., Douglas Aircraft Co., Inc. (El Segundo).

Clopper, J. Allen, A.B., Flight Test Engineer, Fairchild Aircraft Div., Fairchild Engine & Airplane Corp.

Dickson, James J., B.S.M.E. (Aero.), Associate Mech. Engineer, Argonne National Lab.

Drebinger, John W., Ph.D. in Engineering Sciences & Applied Physics, Asst. Project Engineer, Pratt & Whitney Aircraft Div., United Aircraft Corp.

Genevey, M. Louis, Ing. Dipl., Asst. Air Attaché, Office of the Air Attaché, French Embassy.

Gile, Howard L., B.S.M.E., Field Engineer—Engineering Representative, General Electric Co.

Graham, Harry J., B.S. in M.E., Asst. Chief Engineer, Avico Mfg. Co.

Holden, Frederick R., B.M.E., Supervisor, Thermodynamics Section, Engineering & Development Services Div., Naval Air Development Center (Johnsville).

Johannesen, Niels H., M.Sc., Research Engineer, Fluid Motion Lab., The University of Manchester.

Naiman, Irven, B.S., Research Physicist, Hughes Aircraft Co.

Nesbitt, F. Glen, B.S.M.E., Aero. Application Engineer, Sperry Gyroscope Co. Div., The Sperry Corp.

Petry, Ruth M., A.B., Executive Asst., Crash Injury Research, Cornell University Medical College.

Reiutz, Jule J., Designer "A," Douglas Aircraft Co., Inc. (El Segundo).

Weinberg, Morton I., B.S. in M.E., Group Leader, Guided Missile Preliminary Design, Bell Aircraft Corp.

Weinig, Friedrich, Dr. Ing., Aerodynamic Development, General Electric Co.

Wunner, George W., M.S., Mgr., Sales & Installation Engineering Dept., Propeller Div., Curtiss-Wright Corp.

Transferred to MEMBER Grade

Doty, Paul R., B.Ae.E., Aero. Development Control Engineer, Air Materiel Command, Wright-Patterson Air Force Base.

Gordon, William R., B.S.M.E., Group Engineer, Power Plant, Lockheed Aircraft Corp.

Smith, Roy V., M.S. in M.E., Stress Analyst, Rhodes Lewis Co.

Steele, Paul E., B.S. in Ae.E., Aerodynamicist, Preliminary Design Projects, North American Aviation, Inc.

Susag, M. Philip, B.Ae.E., Designer "A," Design Analysis Group, Pratt & Whitney Aircraft Div., United Aircraft Corp.

Wandzura, Bohdan I., B.S. in Ae.E., Aerodynamicist, Hughes Aircraft Co.

Werback, William J., M.S. (Aero.), Hydrodynamics Engineer, Consolidated Vultee Aircraft Corp. (San Diego).

Elected to Associate Member Grade

Benz, Robert, Lt. Comdr., U.S.N.; presently assigned to the Harvard Business School for Master's Degree in Bus. Admin.

Campbell, G. Lewis, M.E., Scientific Reports Analyst, Central Air Documents Office, Air Materiel Command, Wright-Patterson Air Force Base.

Ditchmen, George B., Aircraft Engineer, Self-Employed.

Everhart, Leon P., A.A., Field Service Representative, Lockheed Aircraft Corp.

Lewis, Evan, Airline Capt., Trans World Airlines.

Lewis, Roger, B.A., Dir. of Sales, Curtiss-Wright Corp.

Little, Willard S., Jr., B.S., Technical Representative, Aviation Dept., Shell Oil Co.

Showalter, Joseph S., Secretary-Treasurer (Mgr.), The Showalter Corp.

Topping, Edward W., President & Treasurer, Topping, Inc.

The Bell H-12 Helicopter
Designed and produced for the U. S. Air Force, it is the largest helicopter in the familiar Bell series. Photo courtesy of Bell Aircraft Corp., Buffalo, N. Y.
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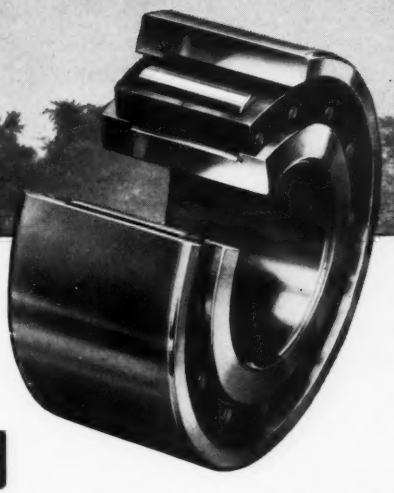

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Elected to Technical Member Grade

DiGiorgio, Frank D., Tool Engineering Draftsman, The Glenn L. Martin Co.

Grey, Jerry, M.S. (Engineering Physics), Graduate Student & Technical Asst., California Institute of Technology.

Kimpton, Henry E., Jr., Engineer—Flight Test, A. V. Roe Canada Ltd.

Lemmerman, Richard D., S.B., Vice-President, Industrial Sound Control, Inc.

Morrell, Bruce E., B.S.M.E., 1st Lt., U.S.A.F.; Research & Development, Hq., Air Materiel Command, Wright-Patterson Air Force Base.

Rodden, William P., M.S., Stress Analyst "B," Douglas Aircraft Co., Inc. (El Segundo).

Roe, Marshall H., B.S., Aerodynamicist "B," North American Aviation, Inc.

Towler, Bernard, Aircraft Design Draftsman, A. V. Roe Canada Ltd. (Malton).

Transferred to Technical Member Grade

Bennett, John M., B.S., Major, U.S.A.F.; Pilot & Aircraft Maintenance Officer, Kelley Air Force Base.

Braden, Henry F., Jr., B.S., Jr. Design Engineer, Consolidated Vultee Aircraft Corp. (Ft. Worth).

Brown, Richard H., Technical Writer, North American Aviation, Inc.

Brunsman, George E., B.S.Ae.E., 1st Lt., U.S.A.F.; Navigator, Radar Observer, Connally Air Force Base.

Carlson, Frank J., B.S.E., Jr. Engineer, Bell Aircraft Corp.

Chase, Edward L., B.S. in M.E. (Aero.), Draftsman "B," North American Aviation, Inc.

Chiu, Tim, B.S.Ae.E.

Cisco, Guy C., Jr., B.S.Ae.E., 2nd Lt., U.S.A.F. (Connally Air Force Base).

Coles, Harold G., Jr., B.S. in M.E. (Aero.), Mathematician "B," North American Aviation, Inc.

Crowder, William E., Jr., B.S. in A.E., Aerodynamicist—Mathematician "B," Stability & Control Section, North American Aviation, Inc.

Daniel, Arnold, Jr., Engineering Draftsman, Lockheed Aircraft Corp. (Georgia).

Doyle, Francis X., B. of Ae.E., Project Engineer in Subsonic Wind-Tunnel Testing, Aerodynamic Lab., David Taylor Model Basin, Dept. of the Navy.

Dunlap, John J., Jr., Engineer—Draftsman "B," Northrop Aircraft, Inc.

Dunning, Leslie L., B.S., Captain & Pilot, 403rd T.C. Wing, Portland Air Force Base.

Ewton, Guy, Jr., B.S., Graduate Student in Aeronautical Engineering, University of Michigan.

Gerardi, Joseph A., Jr., B.S. in Aero., Static Test Engineer, Stress Group, Grumman Aircraft Engineering Corp.

Gonnerman, La Verne W., B.S. in Ae.E., Capt., Pilot, & Academic Instructor, Air Navigation, U.S.A.F.

Hanrahan, Timothy H., B.S.

Hinchey, James F., B.S. in Ae.E., Engineer, Controls Group, Kaman Aircraft Corp.

Hodapp, Walter B., B.S. in Ae.E., Jr. Engineer, Products Div., Bendix Aviation Corp.

Johnson, Gordon W., Engineering Draftsman "B," North American Aviation, Inc.

Jolda, Florian J., B.S., 2nd Lt. & Student Pilot, U.S.A.F. (Goodfellow Air Force Base).

Jones, Floyd D., B.S.A.E., Aero. Engineer, Wright-Patterson Air Force Base.

Jones, Ira P., Jr., B.E., Aero. Research Scientist, N.A.C.A. (Edwards Air Force Base).

Jurgensen, Karl H.

Knox, Robert F., B.S.M.E., Jr. Design Engineer, Chance Vought Aircraft Div., United Aircraft Corp.

Keever, Gerald H., Chief Machinist Mate, Instructor for Recruit Training, U.S.N.

Lewis, Glenn H., B.S. Aero., Engineer GS-5, Wright-Patterson Air Force Base.

Limmer, Theodore H., Jr., Production Test Pilot, Lockheed Aircraft Corp.

Lowe, Walter H., B.S. in A.E., Engineering Draftsman "B," Lockheed Aircraft Corp.

Luoto, Reino E., B.S., Draftsman, Douglas Aircraft Co., Inc. (Santa Monica).

Lynn, Robert R., M.S. in Ae.E., Flight Analyst, Helicopter Div., Bell Aircraft Corp.

Marcinek, Jack J., M.S. in Fluid Dynamics, Development Engineer, Aerojet Engineering Corp.

Martin, Reese S., B.S., Capt., U.S.A.F.; Airplane Commander & Maintenance Test Pilot (Randolph Air Force Base).

Matos, Stephen R., B.Ae.E., Project Engineer, H. E. Pinkerton & Co.

Mayer, George F., B.A.E., Structures Engineer, Grumman Aircraft Engineering Corp.

McQueen, Kenneth T., A.E., Graduate Student, Princeton University.

Menco, William M., B.S. in Ae.E., Jr. Engineer—Aerodynamics, Chance Vought Aircraft Div., United Aircraft Corp.

Miller, Donald D., B.S.A.E., Engineering Draftsman "B," Lockheed Aircraft Corp.

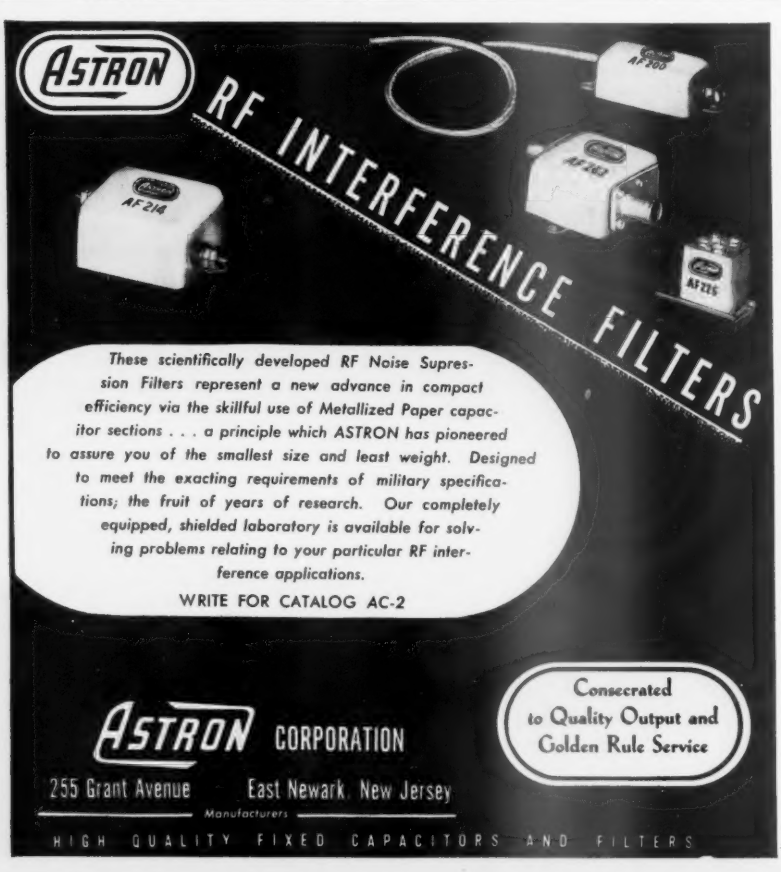
Mundorff, John L., B. of A.E., Lt. Col., U.S.A.F.; Engineering Div., Hq., U.S.A.F. (Washington, D.C.).

Murphree, William D., M.S. in Engineering, Intermediate Scientist, Research Div., Redstone Arsenal, Rohm & Haas Co.

Notess, Charles B., M.E., Asst. Engineer, Flight Research Dept., Cornell Aero. Lab., Inc.

Ozier, Joe W., Production Test Pilot, Lockheed Aircraft Corp.

Pagoria, Nick R., B.S. in Ae.E., Pvt., U.S.A.; Assigned as Stress Analyst, Redstone Arsenal.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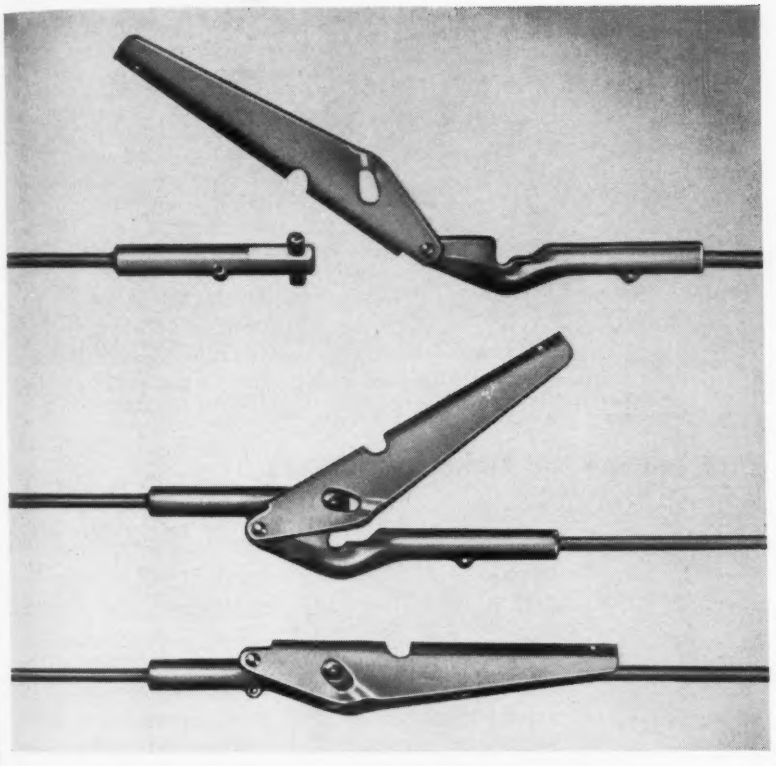

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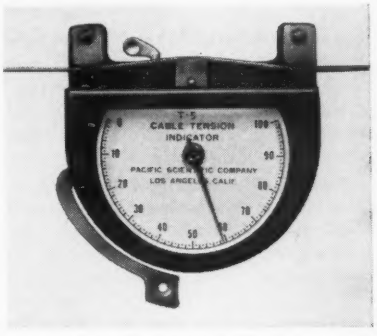

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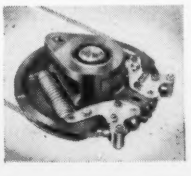

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Penn, William W., Jr., M.S. in Ae.E., Capt., U.S.A.F.; Project Engineer in Wind Tunnel Branch, Air Materiel Command, Wright-Patterson Air Force Base.

Pernick, Leonard J., B.S. in Ae.E., Aero. Engineer, Parachute Branch, Engineering Div., Test & Fabrication Unit, Air Materiel Command, Wright-Patterson Air Force Base.

Pettey, Robert H., Jr., B. of Ae.E., Designer-Draftsman, Ordnance Guided Missiles Center, Redstone Arsenal.

Petty, Allious L., Jr., B.S.

Reece, J. William, S.B., Research Asst., Special Project Dept., Cornell Aero. Lab., Inc.

Ricles, Robert E., B.A.E., Aerodynamicist, Guided Missile Research, Douglas Aircraft Co., Inc. (Santa Monica).

Riley, Robert L., B.S. in Aero., Mathematician "B," Structures Dept., North American Aviation, Inc.

Rooney, Thomas R., B.E. (A.E.), Stress Analyst, Aero Loads Group, North American Aviation, Inc.

Rose, Charles H., M.S.M.E., Supervisor of Stress Analysis, Aerophysics Lab., North American Aviation, Inc.

Salbany, Luiz F., Engineer, Portuguese Govt.

Schnyer, Arnold D., B.S.A.E.

Scotch, Anthony, B.S. in Ae.E., Jr. Design Engineer, Fuselage Group, Consolidated Vultee Aircraft Corp.

Sedvert, Theodore W., B.S.A.E., Capt., U.S.A.F.; Personnel Officer, 122nd Fighter Intercepter Group (Baer Field).

Shrage, Sydney, B.S.E.Ae.E. & B.S.E. Math., Power-Plant Analyst, Chance Vought Aircraft Div., United Aircraft Corp.

Simmons, John H., Jr., Apprentice Engineer, Stress Dept., Aero Design & Engineering Co.

Smith, Norman, B.S.Ae.E., Aero. Engineer, Aerodynamic Research Group, Office of Air Research, Air Materiel Command, Wright-Patterson Air Force Base.

Smith, Rodman, Engineering Draftsman, Hughes Aircraft Co.

Smith, Willard A., B.S. in Ae.E., Field Service Engineer, Boeing Airplane Co. (Seattle).

Stanley, Kenneth M.

Stephens, Cecil A., Weight Analyst "B," North American Aviation, Inc.

Tatro, Robert E., B.S.Ae.E., Detail Engineer, Test Group, Allison Div., General Motors Corp.

Turner, Eugene L., B.S., Servomechanisms Engineer, Bell Aircraft Corp.

Venneman, Walter F., B.M.E., Test Engineer, Gas Turbine Div., General Electric Co.

Wade, Lawrence B., Weight Analyst "B," Northrop Aircraft, Inc.

Warren, Richard L., B.S., Lt., U.S.A.F.; Asst. Aircraft Maintenance Officer, 306th Maintenance Sq., McDill Air Force Base.

Watson, John H., B.S., Aero. Engineer, Preliminary Design, Aircraft Lab., Air Materiel Command, Wright-Patterson Air Force Base.

Wilcox, Allison J., Engineering Draftsman, Northrop Aircraft, Inc.

Yee, Ronald N. N., B.S.Ae.E., Jr. Engineer, Chance Vought Aircraft Div., United Aircraft Corp. (Dallas).

Yoder, Richard, B.Ae.E.

Zimmerman, Arthur H., B.S.Ae.E., Rocket Section Engineer, Bell Aircraft Corp.

Oil System for Turbojet and Turboprop Engines

(*Continued from page 19*)

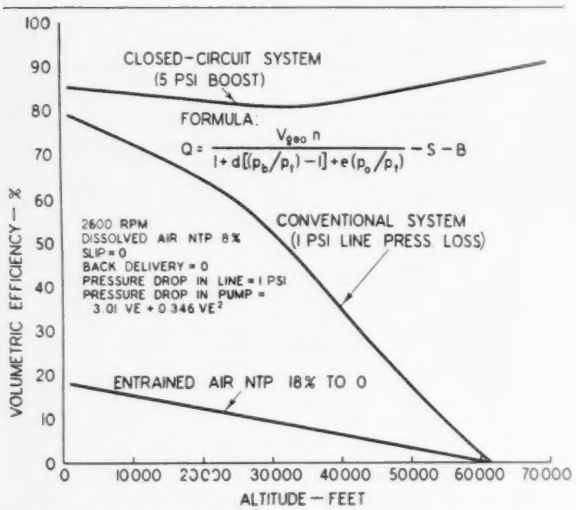

FIG. 12. Calculated volumetric efficiency of pressure pump.

on the contrary, it frequently rises. This result, however, can also be derived by theoretical analysis.

Fig. 10 represents the calculated volumetric efficiency of a gear pump with varying inlet pressure (altitude) and aeration. The percentage of the entrained air is marked on the curve, while the percentage of dissolved air is assumed to be 8 per cent throughout. The curves correspond to the equation shown on the figure that was developed by the author.[2, 3]

With a conventional lubrication system, Fig. 11 represents the minimum oil tank pressures (maximum altitudes) for various degrees of entrained air which would ensure minimum lubrication (this is arbitrarily taken as one-half of sea-level circulation). It will be noted that with 10 per cent aeration the lubrication breaks down at 32,000 ft. altitude.

In order to compare the theoretical performance of the conventional and the closed-circuit system, it was assumed that the pressure loss in pounds per square inch in the gear pump is

$$\text{Pressure loss (lbs. per sq.in.)} = 3.05\ (\text{vol. eff.}) + 0.353\ (\text{vol. eff.})^2$$

and that the volumetric ratio of entrained air in the pressure pump is

$$\text{Entrained air (NTP)} = 0.18 - [0.000003 \times \text{altitude (ft.)}]$$

both realistic assumptions. With these assumptions the volumetric efficiency of the pressure pump was calculated and gave the curves shown in Fig. 12. It is seen that the delivery with the conventional system falls gradually to zero at 61,000 ft., while with the closed-circuit system it is maintained and even rises at high altitudes.

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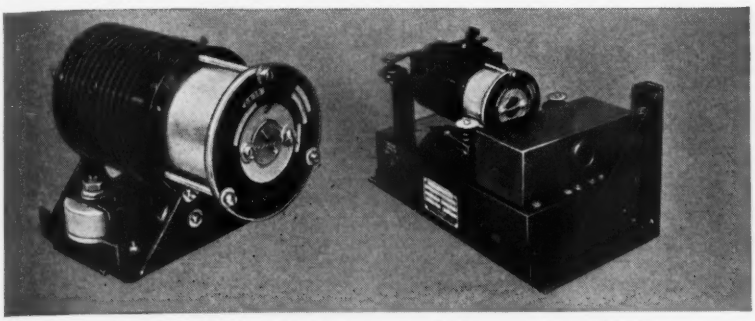

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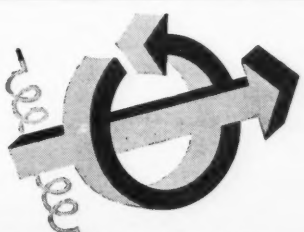

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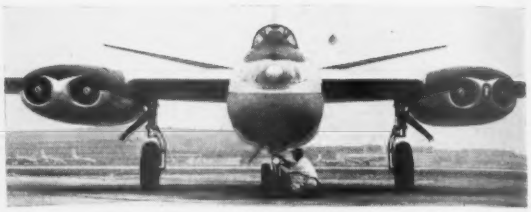

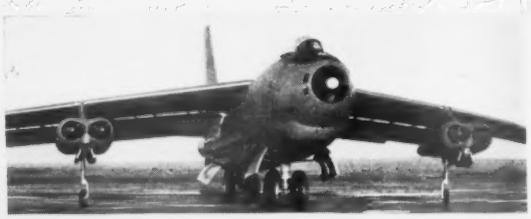

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The abstracts are classified according to the Air Technical Index Distribution Guide. Numbers in parentheses indicate the position of the Division Headings in the numerical arrangement.

Aerodynamics (2) ... 86
- Boundary Layer ... 86
- Control Surfaces ... 86
- Fluid Mechanics & Aerodynamic Theory ... 86
- Internal Flow ... 88
- Performance ... 88
- Stability & Control ... 88
- Wings & Airfoils ... 88

Air Transportation (41) ... 91

Airplane Design & Description (10) ... 92
- Airplane Descriptions ... 92
- Cockpit & Control Cabin ... 92
- Development Testing ... 92
- Ejection Seats ... 92
- Wing Group ... 92

Airports (39) ... 92

Aviation Medicine (19) ... 92

Comfortization (23) ... 94

Education & Training (38) ... 94

Electronics (3) ... 94
- Antennas ... 94
- Circuits & Circuit Elements ... 94
- Communications ... 96
- Components ... 96
- Electronic Tubes ... 96
- Measurements & Testing ... 96
- Navigation Aids ... 96
- Saturable Reactors ... 96
- Telemetry ... 96
- Transmission Lines ... 98
- Wave Propagation ... 98

Equipment ... 98
- Electrical (16) ... 98
- Hydraulic (20) ... 98

Flight Operating Problems (31)
- Ice Prevention & Removal ... 98
- Piloting Technique ... 98
- Weather Hazards ... 98

Flight Safety & Rescue (15) ... 98

Flight Testing (13) ... 98

Fuels & Lubricants (12) ... 98

Gliders (35) ... 100

Guided Missiles (1) ... 100

Instruments (9) ... 100

Laws & Regulations (44) ... 101

Machine Elements (14)
- Friction ... 101
- Gears & Cams ... 101
- Shafts & Rotating Discs ... 101
- Springs ... 101
- Transmissions, Clutches, & Drives ... 102

Maintenance (25) ... 102

Materials (8) ... 102
- Ceramics & Ceramals ... 102
- Metals & Alloys ... 102
- Nonmetallic Materials ... 104
- Sandwich Materials ... 104

Meteorology (30) ... 104

Military Aviation (24) ... 106

Navigation (29) ... 106

Ordnance & Armament (22) ... 106

Photography (26) ... 106

Power Plants ... 106
- Jet & Turbine (5) ... 106
- Reciprocating (6) ... 108
- Rocket (4) ... 108

Production (36) ... 108

Propellers (11) ... 110

Reference Literature (47)
- Bibliographies ... 110
- Yearbooks ... 110

Rotating Wing Aircraft (34) ... 110

Sciences, General (33)
- Mathematics ... 111
- Physics ... 111

Space Travel ... 111

Structures (7) ... 111

Thermodynamics (18) ... 115

Water-Borne Aircraft (21) ... 115

Wind Tunnels & Research Facilities ... 117

II. BOOKS REVIEWED IN THIS ISSUE

Methods of Operations Research. Philip M. Morse and George E. Kimball ... 119
Reviewed by Col. Howard M. McCoy, U.S.A.F.

Mathematics of Relativity. G. Y. Rainich ... 119
Reviewed by Dr. Stephen J. Zand, Lord Manufacturing Company

Guided Missiles. Frank Ross, Jr. ... 120
Reviewed by Alfred Africano, Curtiss-Wright Corporation

Book Notes ... 123

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Aerodynamics (2)

Flight Research. I, II. Handel Davies. *Flight*, Vol. 59, Nos. 2196, 2197, February 23, March 2, 1951, pp. 212–214; 262–264; illus. (Summary of an R.Ae.S. lecture, February 15, 1951: Some Aspects of Flight Research.) Developments in flight research, concerned with aircraft drag reduction, stability and control problems, and general aerodynamics.

Some Aspects of Flight Research. Handel Davies. *The Aeroplane*, Vol. 80, No. 2167, March 2, 1951, pp. 267, 268, illus. (Summary of an R.Ae.S. lecture, February 15, 1951.)

BOUNDARY LAYER

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Derivation of general equations of boundary-layer flow in an appropriate system of orthogonal coordinates to show the importance of the curvature in the equations. In three-dimensional flow, curvature effects are present; they do not disappear as they do in two-dimensional flow theory.

Rotation of an Infinite Plane Lamina; Boundary Layer Growth; Motion Started Impulsively from Rest. Swami Dayal Nigam. *Quarterly of Applied Mathematics*, Vol. 9, No. 1, April, 1951, pp. 89–91, illus. 1 reference.

Growth of rotational motion of an infinite-plane lamina in a viscous fluid; the thickness of the boundary layer increases proportionally with the square root of the time. The equations of motion in cylindrical coordinates are integrated to give the initial motion, using the approximations of boundary-layer theory.

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Effect of Pressure Gradient on Stability and Skin Friction in Laminer Boundary Layers in Compressible Fluids. Herschel Weil. *Journal of the Aeronautical Sciences*, Vol. 18, No. 5, May, 1951, pp. 311–318, illus. 13 references.

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The superposition method of analysis assumes that the form of the velocity profile is the result of two effects, one associated with the wall shear stress and the other associated with the pressure recovery. This theory gives an equation that approximates measured velocity profiles and leads to a reasonable expression for the wall shear-stress coefficient. The pressure-component parameter is used to predict the occurrence of separation.

CONTROL SURFACES

Wind-Tunnel Investigation at Low Speed of Lateral Control Characteristics of an Untapered 45° Sweptback Semispan Wing of Aspect Ratio 1.59 Equipped with Various 25-Percent-Chord Ailerons. Harold S. Johnson and John R. Hagerman. *U.S., N.A.C.A., Technical Note No. 2316*, March, 1951. 31 pp., illus. 13 references.

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Flight Tests on a Falcon with Spoiler Lateral Control. C. E. Kerr. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2491*, 1950 (December, 1941). 7 pp., illus. 2 references. British Information Services, New York. $0.50.

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Evaluation of fluid resistance in accelerated motion includes a term of added mass, which is a constant k times the mass of fluid displaced by the body. Values of k obtained from previous investigations are tabulated along with the experimental conditions. A resistance equation is developed from model-law considerations which is identical with the normal resistance equation for steady flow, except for the addition of a constant that is a function of Reynolds Number, Froude's modulus, the geometry of the body, and a resistance modulus AL/V^2 (A = acceleration, L = characteristic length, V = velocity). This modulus is checked by experiments with circular discs.

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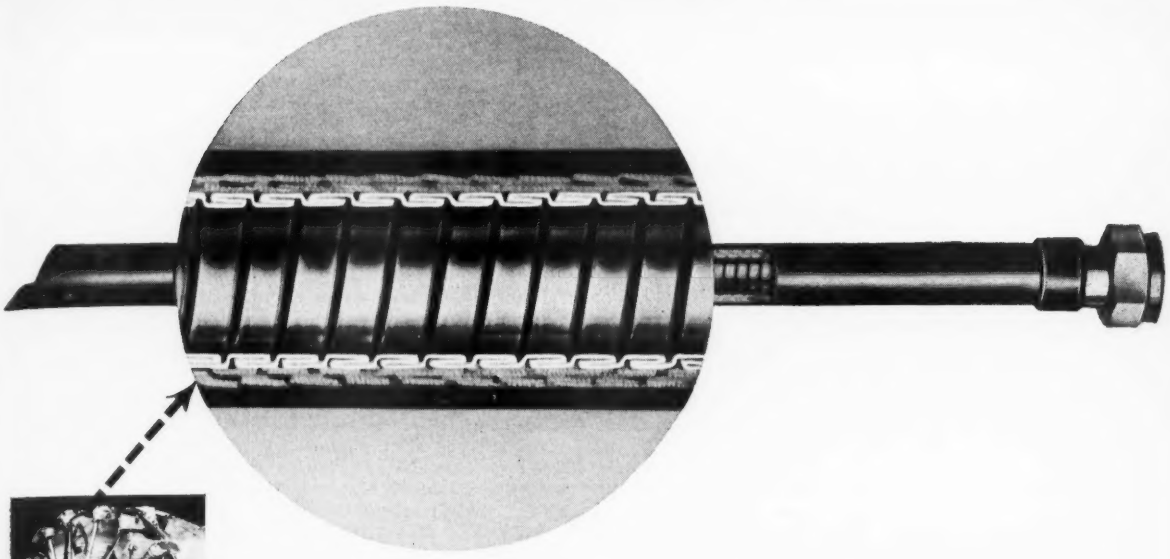
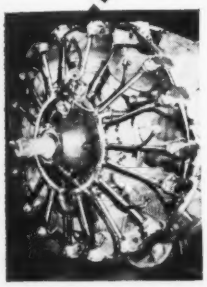
Rotation of an Infinite Plane Lamina; Boundary Layer Growth; Motion Started Impulsively from Rest. Swami Dayal Nigam. *Quarterly of Applied Mathematics*, Vol. 9, No. 1, April, 1951, pp. 89–91, illus. 1 reference.

The equations of motion in cylindrical coordinates are used to study the initial growth of motion effected by suddenly causing an infinite plane lamina to rotate with constant angular velocity about an axis; the thickness of the resultant boundary layer is proportional to the square root of the time. The radial, azimuthal, and axial components of velocity and pressure are substituted into the equations of motion, and, by the use of boundary-layer theory, the solutions of the initial motion are obtained.

Generalization of Boundary-Layer Momentum-Integral Equations to Three-Dimensional Flows Including Those of Rotating System. Artur Mager. *U.S., N.A.C.A., Technical Note No. 2310*, March, 1951. 47 pp., illus. 18 references.

The Navier-Stokes equations of motion and the equation of continuity are transformed so as to apply to an orthogonal curvilinear coordinate system rotating with a uniform angular veloc-





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ity about an arbitrary axis in space. These equations are simplified, and an approximate solution in closed integral form is obtained for a generalized boundary-layer momentum-loss thickness and flow deflection at the wall in the turbulent case.

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An attempt to provide shorter and simpler solutions for calculating the velocity distribution for an airfoil cascade and the airfoil shape for a prescribed velocity distribution. The relations are developed by use of the method of singularities.

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A series of calculations, based on experimental cascade and single-stage studies, was carried out to obtain the performance of a six-, an eight-, and a 13-stage compressor, each designed for the same tip speed, to handle the same mass flow, and to develop a pressure ratio of 3.2.

A General Through-Flow Theory of Fluid Flow with Subsonic or Supersonic Velocity in Turbomachines of Arbitrary Hub and Casing Shapes. Chung-Hua Wu. *U.S., N.A.C.A., Technical Note No. 2302*, March, 1951. 40 pp., illus. 14 references.

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Investigation of Turbulent Flow and Heat Transfer in Smooth Tubes, Including the Effects of Variable Fluid Properties. R. G. Deissler. *American Society of Mechanical Engineers, Transactions*, Vol. 73, No. 2, February, 1951, pp. 101–107, illus. 11 references.

Derivation of an equation for the velocity distribution close to a smooth wall which represents both the laminar and the buffer layers. This equation and von Kármán's solution for flow at a distance from the wall were extended to include flow with heat transfer for a fluid with a Prandtl Number of 1 where there is an appreciable variation of fluid properties due to temperature variation across the tube.

Discussion: An Investigation of Ejector Design by Analysis and Experiment, by J. H. Keenan, E. P. Neumann, and F. Lustwerk. Walton Forstall, Jr., and A. H. Shapiro. **Authors' Closure.** *Journal of Applied Mechanics*, Vol. 18, No. 1, March, 1951, p. 117. 1 reference. Limitations of the one-dimensional method of analysis.

Further Experiments on the Flow and Heat Transfer in a Heated Turbulent Air Jet. Stanley Corrsin and Mahinder S. Uberoi. *U.S., N.A.C.A., Report No. 998*, 1950. 17 pp., illus. 24 references. Superintendent of Documents, Washington. $0.20.

Investigation of the effect of mean-density differences on the rate of spread of a jet and of the relative rates of transfer of heat and momentum in a heated jet. An approximate analysis results in obtaining the relative jet spread as a function of the density, without fully solving the integral problems. A hot-wire technique is developed for simultaneously measuring temperature and velocity fluctuations; the weaknesses and limitations of the process are analyzed.

Compressible Supersonic Flow in Jets Under the Kármán-Tsien Pressure-Volume Relation. N. Coburn. *Journal of Applied Physics*, Vol. 22, No. 2, February, 1951, pp. 124–130, illus. 5 references.

Development of an analytic method for treating fairly uniform supersonic flows in jets with free streamlines; two arbitrary functions completely determine the von Kármán-Tsien flow. The periodic recurrence of the free-stream jet boundary is explained by a folding property of the map of the flow in the hodograph plane.

A New Method of Designing Two-Dimensional Laval Nozzles for a Parallel and Uniform Jet. Kuno Foelsch. *North American Aviation, Inc., Report No. NA-46-235-2*, May 27, 1946. 48 pp., illus. 4 references.

PERFORMANCE

Correspondence: Flight on Asymmetric Power. Eric L. Beverly. **Author's Reply.** E. Wright. *Aircraft Engineering*, Vol. 23, No. 265, March, 1951, p. 85.

The Steepest Angle of Climb of Jet Aeroplanes in Unaccelerated Flight. Elias Järvineva. *Aircraft Engineering*, Vol. 23, No. 265, March, 1951, pp. 76, 77, illus. 1 reference.

Derivation of the equations for the least thrust sufficient for a given angle of climb for jet aircraft. The equations are transformed to allow the steepest angle of climb, flight velocity, and rate of climb to be represented as a simple, dimensionless vector diagram.

STABILITY & CONTROL

The Effects of Mass Distribution on the Low-Speed Dynamic Lateral Stability and Control Characteristics of a Model with a 45° Sweptback Wing. Donald E. Hewes. *U.S., N.A.C.A., Technical Note No. 2313*, March, 1951. 27 pp., illus. 11 references.

Determination of the trends in low-speed dynamic lateral stability and control characteristics produced by large variations of the mass distribution of a free-flying model with a 45° sweptback wing of taper ratio 0.6 and aspect ratio 4. The value of the relative-density factor was held constant.

WINGS & AIRFOILS

Nonstationary Motion of Purely Supersonic Wings. Jack E. Froehlich. *Journal of the Aeronautical Sciences*, Vol. 18, No. 5, May, 1951, pp. 298–310, illus. 12 references.

General theory of the nature of the total forces acting on an oscillating three-dimensional wing with supersonic edges. The forces acting on a delta wing due to rolling, plunging, and pitching oscillations are calculated for $M = 1.25$ and 2.00 as a function of the frequency.

Source-Superposition Method of Solution of a Periodically Oscillating Wing at Supersonic Speeds. H. J. Stewart and Ting-

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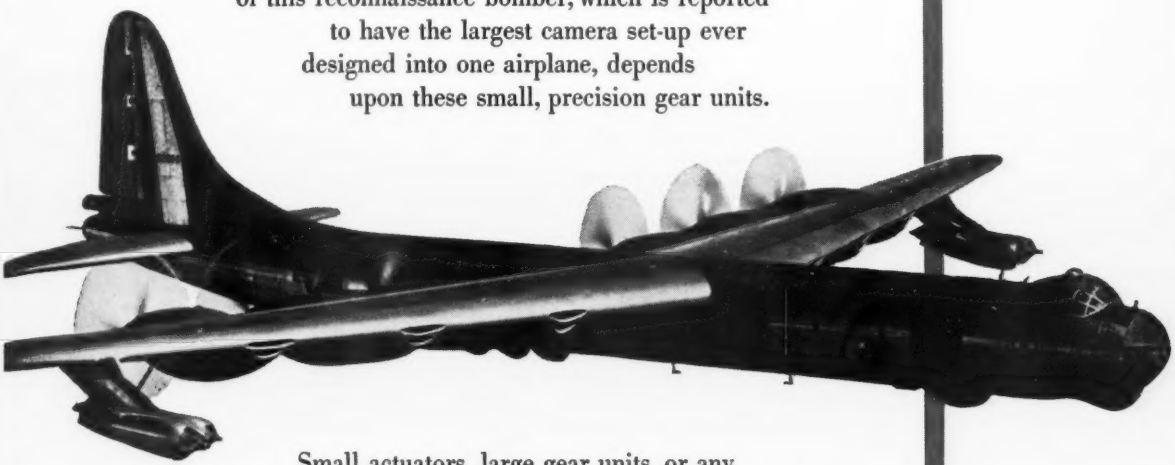

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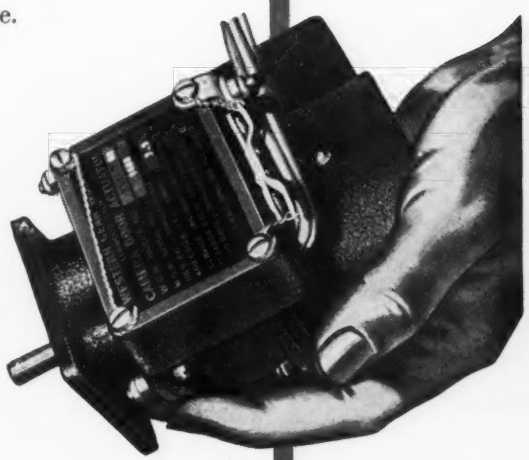

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Yi Li. *Quarterly of Applied Mathematics*, Vol. 9, No. 1, April, 1951, pp. 31–45, illus. 8 references.

Analysis of the nonsteady lift of finite wings at supersonic speeds, particularly in regions influenced by subsonic leading edges or wing tips. The equivalent-area method for the steady-state case is extended to oscillating wings.

The Oscillating Rectangular Airfoil at Supersonic Speeds. John W. Miles. *Quarterly of Applied Mathematics*, Vol. 9, No. 1, April, 1951, pp. 47–65, illus. 16 references.

The Fourier transform solution of the linearized, potential equation for supersonic flow which determines the pressure distribution on a two-dimensional oscillating airfoil is extended to give the pressure distribution on a (three-dimensional) rectangular airfoil that has an aspect ratio large enough so that the Mach waves from the leading-edge wing tips do not intersect forward of the trailing edge. Results can be applied indirectly to the case where the Mach waves intersect on the wing but do not intersect the opposite side edges.

A Method for the Determination of the Spanwise Load Distribution of a Flexible Swept Wing at Subsonic Speeds. Richard B. Skoog and Harvey H. Brown. *U.S., N.A.C.A., Technical Note No. 2222*, March, 1951. 46 pp., illus. 28 references.

Line-Vortex Theory for Calculation of Supersonic Downwash. Harold Mirels and Rudolph C. Haefeli. *U.S., N.A.C.A., Report No. 983*, 1950. 16 pp., illus. 10 references. Superintendent of Documents, Washington. $0.20.

Derivation of the downwash field induced by a supersonic line vortex of constant slope. The relationship is established between the downwash behind a supersonic lifting surface and the downwash induced by line vortices. The downwash is computed with linearized solutions. A bent lifting-line method is proposed for swept wings; an unbent lifting-line method is proposed for unswept wings.

Comparative Drag Measurements at Transonic Speeds of Rectangular and Sweptback NACA 65-009 Airfoils Mounted on a Freely Falling Body. Charles W. Mathews and Jim Rogers Thompson. *U.S., N.A.C.A., Report No. 988*, 1950. 7 pp., illus. 2 references. Superintendent of Documents, Washington. $0.15.

Drag measurements at a Mach Number range of 0.90–1.27 of an N.A.C.A. 65-009 rectangular airfoil and a 65-009 airfoil sweptback at 45°, to establish a relation between airfoil drag coefficients and free-stream Mach Number.

An Analysis of the Lift on Straight, Yawed and Swept-Back Wings. J. Lockwood Taylor. *The Aeronautical Quarterly*, Vol. 2, Part 4, February, 1951, pp. 293–304, illus. 4 references.

Calculation of finite-chord loss for the straight wing. Finite-chord effect, cosine effect for infinite and finite aspect ratio, gain in lift at the wing tip, and the central kink effect are each calculated for the yawed and sweptback wing. Exact and approximate values of downwash corrections are calculated for a straight wing and compared with the calculated values for a yawed or swept wing.

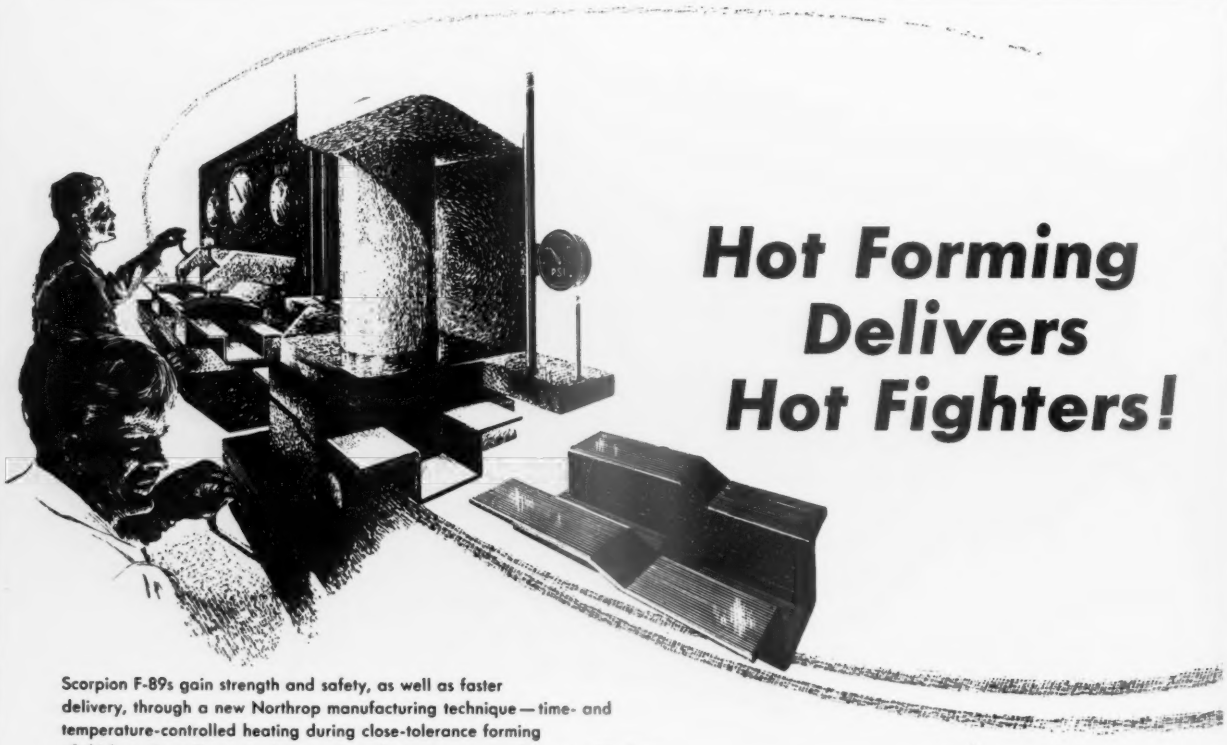
The Aerodynamics of Supersonic Biplanes. W. R. Sears and H. S. Tan. *Quarterly of Applied Mathematics*, Vol. 9, No. 1, April, 1951, pp. 67–76, illus. 8 references.

Study of the aerodynamics of biplanes that have rectangular wings of identical plan form by use of the small-perturbation linear theory in which all shock and expansion waves are replaced by Mach waves inclined at the free-stream Mach angle. A method is developed whereby the velocity potential and all interaction effects are calculated by means of integrations involving the wing-surface slopes only. The results are applied to obtaining numerically the wave drag, at zero lift, of the Busemann biplane of triangular wing sections.

Applications of von Kármán's Integral Method in Supersonic Wing Theory. Chieh-Chien Chang. *U.S., N.A.C.A., Technical Note No. 2317*, March, 1951. 71 pp., illus. 19 references.

Derivation of von Kármán's integral method in terms of the physical, rather than mathematical, approach. The procedure is applied to find the wave drag of a tapered sweptback wing and is used for the development of a system for evaluating, for a given lift distribution, the downwash angle anywhere in the plane of the wing. The method allows the complete physical effect of an arbitrary wing to be expressed in terms of one integral.

Theoretical Lift and Damping in Roll at Supersonic Speeds of Thin Sweptback Tapered Wings with Streamwise Tips, Subsonic Leading Edges, and Supersonic Trailing Edges. Frank S.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Malvestuto, Jr., Kenneth Margolis, and Herbert S. Ribner. *U.S., N.A.C.A., Report No. 970*, 1950. 16 pp., illus. 8 references. Superintendent of Documents, Washington. $0.20.

The Reversibility Theorem for Thin Airfoils in Subsonic and Supersonic Flow. Clinton E. Brown. *U.S., N.A.C.A., Report No. 986*, 1950. 3 pp. 9 references. Superintendent of Documents, Washington. $0.15.

A method introduced by Munk is extended to prove that the lift-curve slope of thin wings in either subsonic or supersonic flow is the same when the direction of flight of the wing is reversed. It is also shown that the wing reversal does not change the thickness drag, damping-in-roll parameter, or the damping-in-pitch parameter.

The Aerodynamic Derivatives with Respect to Sideslip for a Delta Wing with Small Dihedral at Supersonic Speeds. J. Hunter Tod and A. Robinson. *College of Aeronautics, Cranfield, England, Addendum to Report No. 12*, December, 1950. 10 pp., illus.

Derivation of the first-order effects due to the distortion of the flow because the axis of a delta wing under sideslip is not aligned with the axis of the Mach cone. Angle of incidence of the delta wing is not zero.

Some Roll Characteristics of Cruciform Delta Wings at Supersonic Speeds. Zegmund O. Bleviss. *Journal of the Aeronautical Sciences*, Vol. 18, No. 5, May, 1951, pp. 289–297, illus. 10 references.

Qualitative analysis using linearized nonviscous theory of roll due to aileron deflection of two opposite fins, damping in roll, and roll induced by pitch and yaw, including the effects of fin-fin, wing-body, and wing-body-tail interference.

Linearized Theory of Conical Supersonic Flow with Application to Triangular Wings. W. D. Hayes, S. H. Browne, and R. J. Lew. *North American Aviation, Inc., Report No. NA-46-818*, June 26, 1947. 56 pp., illus. 8 references.

Investigation at Low Speeds of the Effect of Aspect Ratio and Sweep on Rolling Stability Derivatives of Untapered Wings. Alex Goodman and Lewis R. Fisher. *U.S., N.A.C.A., Report No. 968*, 1950. 11 pp., illus. 7 references. Superintendent of Documents, Washington. $0.15.

Low-scale test in the 6-ft. rolling-flow test section of the Langley stability tunnel on a series of untapered wings with N.A.C.A. 0012 airfoil sections in planes normal to the leading edge. Wings of aspect ratio 1.34, 2.61, and 5.16 were each swept back at 0°, 45°, and 60°.

Correspondence Flows for Wings in Linearized Potential Fields at Subsonic and Supersonic Speeds. Sidney M. Harmon. *U.S., N.A.C.A., Technical Note No. 2303*, March, 1951. 29 pp., illus. 4 references.

Development of a generalized rule for correspondence flows which applies to lifting and nonlifting wings at subsonic and supersonic speeds, including edge corrections for finite plane forms. Several examples are given of the correspondence flows for the rectangular wing at supersonic speeds.

Note on Wing-Nacelle-Airscrew Interference. E. Ower, R. Warden, and R. C. Pankhurst. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2439*, 1950 (June, 1940). 6 pp., illus. 5 references. British Information Services, New York. $0.35.

Air Transportation (41)

Air Traffic Forecasting for the New York–New Jersey Port District. II. Alex L. Hart. *Journal of Air Law and Commerce*, Vol. 18, No. 1, Winter, 1951, pp. 33–35. 1 reference. Cargo and mail estimates (1950–1980) prepared for the Port of New York Authority.

International Air Transport Association (IATA), Sixth Annual General Meeting. *Journal of Air Law and Commerce*, Vol. 18, No. 1, Winter, 1951, pp. 96–98.

International Civil Aviation Organization (ICAO), 11th Session of the Council. Joan H. Stacy. *Journal of Air Law and Commerce*, Vol. 18, No. 1, Winter, 1951, pp. 91–95. 4 references.

Passenger and Cargo Service Standards Required for Local Air Service. Mel Anderson. *S.A.E., National Aeronautic Meeting, New York, April 16–19, 1951, Preprint No. 611.* 4 pp. $0.25.

Requirements for local-service air-line operation, as seen by Lake Central Airlines.

Cost Analysis of the Jetliner (Avro C.102). James M. Venable, Jr. *Aviation Age*, Vol. 15, No. 3, March, 1951, pp. 24, 25, illus. Comparison of operation and maintenance costs of the Avro Jetliner, Douglas DC-3, DC-4, DC-6, and Martin 2-0-2, including direct costs, depreciation, parts, capacity, ranges, and speed.

Making Air Transport Pay. I—IV. Peter Masefield. *Flight*, Vol. 59, Nos. 2195–2198, February 15, 23, March 2, 9, 1951, pp. 182–184; 238–240; 266–269; 293; illus. (Summary of the 9th Brancker Memorial Lecture, Institute of Transport, February 12, 1951: Some Economic Factors in Air Transport Operation, with Particular Emphasis on Short-Haul Services.)

Effects of Competition and Changes in Route Structure on Growth of Domestic Air Travel. Herbert H. Whitehead. *Journal of Air Law and Commerce*, Vol. 18, No. 1, Winter, 1951, pp. 78–90.

American Airlines' study of prewar and postwar air travel to learn the average growth tendencies of the industry. All of the travel was classified so that the effects of added competition and one-carrier service could be evaluated independently. The air traffic covered represented 35 per cent of U.S. domestic air-line travel, 1940–1949.

Subsidies and Competition As Factors in Air Transport Policy. Stanley Berge. *Journal of Air Law and Commerce*, Vol. 18, No. 1, Winter, 1951, pp. 1–11. 12 references.

Review of the testimony before the Senate Committee on Interstate and Foreign Commerce on air-line subsidy and competition; nature and extent of air-transport subsidies; regulation of competition; competition and the public utility concept.

Passenger Fare Policies of the Civil Aeronautics Board. Lucile Sheppard Keyes. *Journal of Air Law and Commerce*, Vol. 18, No. 1, Winter, 1951, pp. 46–77. 31 references.

Airplane Design & Description (10)

Aircraft Ground Handling Characteristics As Required for Maximum Efficiency. James G. Ray. *S.A.E., National Aeronautic Meeting, New York, April 16–19, 1951, Preprint No. 612.* 5 pp. $0.25. General requirements, from touch-down to take-off; flight characteristics involved in landing, taxiing, loading, unloading, and take-off.

Wanted—A New Airplane! T. H. Davis. *S.A.E., National Aeronautic Meeting, New York, April 16–19, 1951, Preprint No. 609.* 10 pp. $0.25. Specifications and requirements for an aircraft designed for efficient operation at flight distances of less than 400 miles.

Power Versus Weight in Aviation; Past History and Present Practice. Maurice Roy. *The Aeroplane*, Vol. 80, No. 2067, March 2, 1951, pp. 264–266, illus. (Summary of a paper.)

Power Versus Weight in Aviation; Past History and Present Practice. Maurice Roy. *Flight*, Vol. 59, No. 2198, March 9, 1951, pp. 290–292, illus. (Summary of a paper.)

AIRPLANE DESCRIPTIONS

Avro (Canada) C.102 Jetliner 4-Engined Turboprop Transport. *Aviation Age*, Vol. 15, No. 3, March, 1951, pp. 24, 25, illus. Operation and maintenance costs.

Cessna 170 5-Place Single-Engined Personal Airplane. *The Aeroplane*, Vol. 80, No. 2068, March 9, 1951, pp. 298, 299, illus. A pilot's report.

Convair Turboliner Twin-Engined Turboprop Transport. *Aviation Week*, Vol. 54, No. 11, March 12, 1951, pp. 21, 22, 25, illus.

Noorduyn Harvard 2 Single-Engined Advanced Trainer, Canada. II—Armament Installations. G. T. Johnson and J. G. Begg. *Canada, Royal Canadian Air Force, Experimental and Proving Establishment, Rockcliffe, Report No. 943 (Final Development Report No. D/154-2)*, January, 1951. 23 pp., illus.

Percival Prince Twin-Engined Transport, England (Aviation Design Progress). Randolph Hawthorne. *Aviation Age*, Vol. 15, No. 3, March, 1951, pp. 26, 27, illus., cutaway drawings.

COCKPIT & CONTROL CABIN

Airline Pilot Questionnaire Study on Cockpit Visibility Problems. George L. Pigman and Thomas M. Edwards. *U.S., Civil Aeronautics Administration, Technical Development Report No. 123*, September, 1950. 38 pp., illus.

DEVELOPMENT TESTING

Ad Hoc; An Account of Some of the Research and Development Testing Which Preceded the First Flight of the Comet. *de Havilland Gazette*, No. 61, February, 1951, pp. 16–19, illus.

EJECTION SEATS

The Navy Ejectable Cockpit. J. C. Farly. *Journal of Aviation Medicine*, Vol. 22, No. 1, February, 1951, pp. 46–49.

Design details of an ejectable cockpit that contains all the pilot and survival equipment; comparison of its performance and effects on the pilot with that of a standard ejection seat.

WING GROUP

Integrally Stiffened Wings in Super Connie. Fred S. Hunter. *American Aviation*, Vol. 14, No. 37, April 2, 1951, pp. 19, 20, 22, illus.

Integrally stiffened panels will be used in the lower wing surfaces (both inner and outer wing panels) of the Lockheed L-1049C Super Constellations built for E.A.L. and T.W.A. This construction gives a reduction in weight and an increase in structural efficiency.

Airports (39)

All-Weather Flying; Impressions of the All-Weather Flying Symposium, Electronics—2 Session, I.A.S. Nineteenth Annual Meeting. R. C. Robson. *Aeronautical Engineering Review*, Vol. 10, No. 5, May, 1951, pp. 44–47, 173, illus.

Report on Stockton Runway Test Section. *U.S., Engineer Office*, Sacramento, Calif., 1942. 82 pp., illus.

Data collected during a test on an experimental runway section. Runway was tested to obtain pavement and base information for wheel-loads corresponding to those of 1942 heavy bombers.

Landing Tee for Airports. R. E. Ohlund. *ASEA Journal*, Vol. 23, No. 12, December, 1950, pp. 167–171, illus.

Welded Bridges and Hangars in Spain. E. Torroja. *Institute of Welding, Transactions*, Vol. 14, No. 1, February, 1951, pp. 13–21, illus.

Aviation Medicine (19)

The Relation of Circulatory Rate to Aeroembolism and Aeroemphysema. J. W. Wedral and A. C. Ivy. *Journal of Aviation Medicine*, Vol. 22, No. 1, February, 1951, pp. 13–21, illus. 10 references.

Acute Nephrosis Following Experimental Local Cold Injury. R. B. Lewis and R. M. Thompson. *U.S., Air Force, School of Aviation Medicine, Randolph Field, Texas, Project 21-23-016, Report No. 1*, November, 1950. 21 pp., illus. 22 references.

Human Tolerance to Deceleration; Summary of 166 Runs. John Paul Stapp. *Journal of Aviation Medicine*, Vol. 22, No. 1, February, 1951, pp. 42–45, 85. Results of U.S.A.F. experiments.

The Effect of Anoxia on Excitatory Mechanisms of the Retina and the Visual Pathway. Werner K. Noell and Hermin I. Chinn. *U.S., Air Force, School of Aviation Medicine, Randolph Field, Texas, Project No. 21-23-012, Final Report*, January, 1951. 43 pp., illus. 61 references.

Biochemical and Blood Pressure Changes in Goats Under Negative G (Acceleration Tailward). R. S. Pogrund, S. W. Ames, and C. F. Lombard. *Journal of Aviation Medicine*, Vol. 22, No. 1, February, 1951, pp. 50–59, 86, illus. 20 references.

The Significance of the Loss of Blood Volume into the Limbs During Pressure Breathing. J. P. Henry. *Journal of Aviation Medicine*, Vol. 22, No. 1, February, 1951, pp. 31–38, illus. 3 references.

Studies in Diffusion Respiration. Tom Shires and S. W. Eyer. *Journal of Aviation Medicine*, Vol. 22, No. 1, February, 1951, pp. 22–30, 38, illus. 10 references.

The Effect of Increased Positive Radial Acceleration upon Perceptual Speed Ability. A. L. Comrey, A. A. Canfield, R. C. Wilson, and W. S. Zimmerman. *Journal of Aviation Medicine*, Vol. 22, No. 1, February, 1951, pp. 60–64, 69. 2 references.

Tests on human subjects in the Navy human centrifuge at the University of Southern California to determine the speed and accuracy of certain perceptual processes. Acceleration for the tests was 1, 2.5, and 4 *g*.

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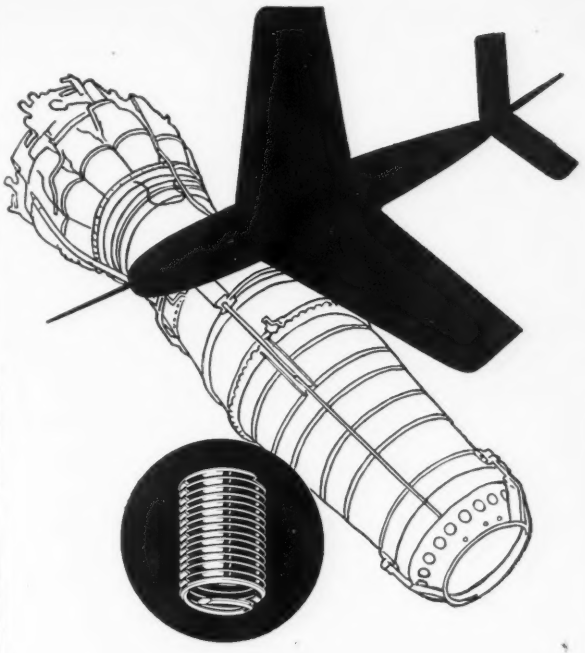

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Prevention of Air Sickness by Benadryl-Scopolamine Mixtures. Hermin I. Chinn, Benjamin A. Strickland, Oliver H. Waltrip, and Samuel H. Gainer. *U.S. Armed Forces Medical Journal*, Vol. 2, No. 3, March, 1951, pp. 401–404. 4 references.

Prophylaxis of Motion Sickness; Evaluation of Some Drugs in Seasickness. Hermin I. Chinn, Werner K. Noell, and Paul K. Smith. *U.S., Air Force, School of Aviation Medicine, Randolph Field, Texas, Project No. 21-32-014, Report No. 4*, October, 1950. 20 pp., illus. 23 references.

The Navy Ejectable Cockpit. J. C. Farly. *Journal of Aviation Medicine*, Vol. 22, No. 1, February, 1951, pp. 46–49.

An ejectable cockpit that provides a positive, safe, emergency separation from high-performance aircraft, and a safe descent and landing. The cockpit becomes a lifeboat at sea and an effective shelter on land.

A Photoelectric Hypoxia Warning Device. Kurt Kramer, Durward F. Timmons, and Harry Mayne. *Journal of Aviation Medicine*, Vol. 22, No. 1, February, 1951, pp. 70–74, 79, illus. 7 references. A hypoxia warning device that consists of a small oximeter built into the headset (of flying personnel) and a d.c. amplifier wired to the oximeter.

Human Decelerator. H. M. Sweeney. *Journal of Aviation Medicine*, Vol. 22, No. 1, February, 1951, pp. 39–41, 49.

U.S.A.F. study of the survival of human subjects exposed to linear forces of short duration and high magnitude. Experimental equipment consisted of a rocket-powered sled, brake, and telemetering equipment that provided controlled linear deceleration.

Comfortization (23)

Seat-Manufacture. I—Design-Considerations and Strength Requirements; Mechanical Testing. L. G. Burnard. *Aircraft Production*, Vol. 13, No. 150, April, 1951, pp. 99–104, illus. Strength and safety requirements; psychological factors in seat design, such as comfort and appearance; types of seats.

Education & Training (38)

Techniques in Training the Military Pilot. John Fricker. *The Aeroplane*, Vol. 80, No. 2068, March 9, 1951, pp. 289–294, illus. R.A.F., Royal Naval Air Training, and R.C.A.F. training procedures compared with the U.S.A.F. training program.

Electronic Trainer. *The Aeroplane*, Vol. 80, No. 2067, March 2, 1951, pp. 274, 275, illus. English version (C.700) of P.A.A.'s Dehmel simulator, which is built by Redifon, Ltd., to simulate B.O.A.C.'s Boeing Stratocruisers.

Flight Simulator. *Flight*, Vol. 59, No. 2198, March 9, 1951, pp. 283–285, illus. A training machine (C.700), built by Redifon, Ltd., for B.O.A.C., represents the Boeing Stratocruiser. It is similar to P.A.A.'s Dehmel simulator.

Training Craftsmen; Development of Natural Aptitudes and Abilities; a Co-Ordinated Group-Scheme. John Loxham. *Aircraft Production*, Vol. 13, No. 149, March, 1951, pp. 67–70, illus.

Learning Theories and Instructional Film Research (Rapid Mass Learning). Kinsley R. Smith and E. B. vanOrmer. (The Pennsylvania State College.) *U.S., Office of Naval Research, Special Devices Center, Technical Report No. SDC-269-7-6*, June, 1949. 12 pp. 16 references.

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Relative Effectiveness of Instruction by: Films Exclusively, Films Plus Study Guides; and Standard Lecture Methods (Rapid Mass Learning). Abram W. VanderMeer. (The Pennsylvania State College.) *U.S., Office of Naval Research, Special Devices Center, Technical Report No. SDC 269-7-13*, July, 1950. 51 pp.

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Overall problems of aircraft electronic equipment standards as dictated by a planned common air-navigation traffic-control system. The problems of implementing aircraft electronics complying with operational and technical system planning are considered, together with a résumé of several active organizations and committees participating in the program.

Packaging of Air-Borne Electronic Equipment. Orville M. Dunning. *Aeronautical Engineering Review*, Vol. 10, No. 5, May, 1951, pp. 29, 30, 41. Criteria for sound packaging design for the subminiaturization of electronic equipment; development, temperature, and mechanical problems.

Electronics in Aviation; A Summary of the Morning Session on Electronics at the I.A.S. Nineteenth Annual Meeting, February 1, 1951. Harold A. Kressly and J. S. Erickson. *Aeronautical Engineering Review*, Vol. 10, No. 5, May, 1951, pp. 14, 15, illus.

Conservation of Critical Materials. W. W. MacDonald. *Electronics*, Vol. 24, No. 4, April, 1951, pp. 84–87, illus.

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Air-Borne Antenna Problems. Harald Schutz. *Aeronautical Engineering Review*, Vol. 10, No. 5, May, 1951, pp. 32–36, illus. Design problems of air-borne antennas for high-speed aircraft which must satisfy the requirements of high electronic efficiency, low drag, and small weight and size.

On the Directional Patterns of Polystyrene Rod Antennas. R. B. Watson. *Journal of Applied Physics*, Vol. 22, No. 2, February, 1951, pp. 154–156, illus. 3 references.

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Reflection and Transmission at the Surface of Metal-Plate Media. Bela A. Lengyel. *Journal of Applied Physics*, Vol. 22, No. 3, March, 1951, pp. 265–276, illus. 9 references.

CIRCUITS & CIRCUIT ELEMENTS

A Digital Electronic Correlator. Henry E. Singleton. *Massachusetts Institute of Technology, Research Laboratory of Electronics, Technical Report No. 152*, February 21, 1950. 30 pp., illus. 10 references.

Design of a digital electronic correlator for communication problems. The computer uses binary digital techniques for multiplication, integration, and storage. General design specifications and details include block and circuit diagrams of the components.

Standards on Electronic Computers: Definitions of Terms, 1950 (Standard No. 50 IRE 8.S1). *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 3, March, 1951, pp. 271–277.

Frequency-Coordinate Vector Diagram. Philip F. Ordung and Herbert L. Krauss. *Franklin Institute, Journal*, Vol. 251, No. 3, March, 1951, pp. 343–350, illus. Development of a method of visualizing the frequency response of a circuit by constructing a vector diagram from the response function.

Lattice-Type Crystal Filter. Richard Lowrie. *Electronics*, Vol. 24, No. 4, March, 1951, pp. 129–131, illus. 2 references.

A band-pass filter centered at 2 mc. with a pass band of approximately 4,000 cycles. A lattice circuit was used to obtain maximum sensitivity; this filter design can be used at any frequency for which good crystals can be obtained.

Independent Control of Selectivity and Bandwidth. Oswald G. Villard, Jr. *Electronics*, Vol. 24, No. 4, April, 1951, pp. 121–123, illus. 1 reference.

A simple RC amplifier provides a wide range of bandwidth-frequency relationships without affecting selectivity or gain. It can be made to give constant absolute bandwidth in cycles per sec. for different center frequencies throughout audio range.

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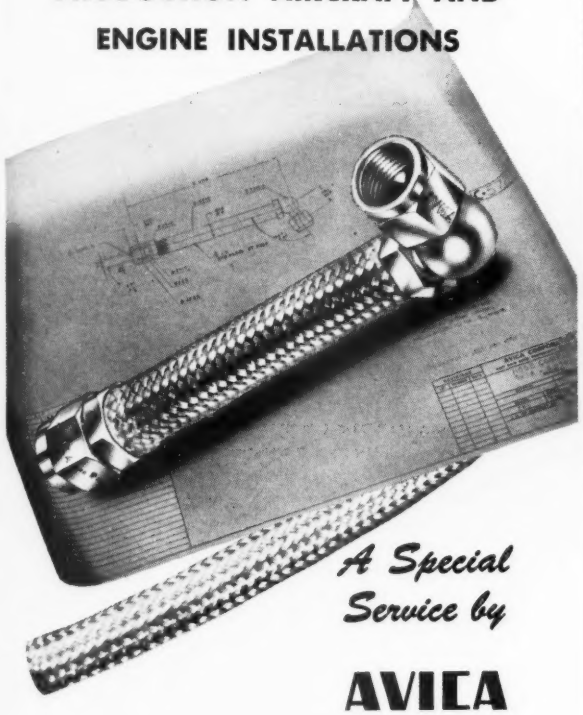

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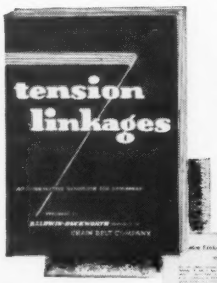

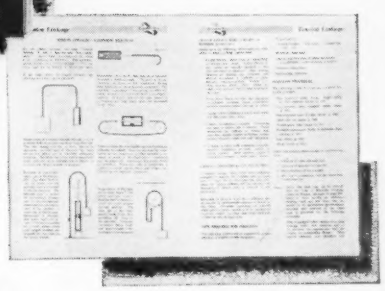

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Simplified Electronic Switch for Oscilloscopes. L. N. Van Allen. *Electronics*, Vol. 24, No. 4, April, 1951, p. 136, circuit diagr. A simple electronic switch that is triggered by the horizontal sweep generator in the oscilloscope is used to obtain two simultaneous and independent traces.

The Electronic Dynamic Balancing Machine. S. A. Rybczynski. *Electronics Forum*, No. 19, September, 1950, pp. 18–31, illus.

The Dawes Instruments Dynamic Balancing Machine, Type 1250, is a bench instrument that quickly and accurately determines the position and amount of unbalance of small rotor units and armatures. Block and circuit diagrams show the make-up and operation of the instrument.

Magnetostrictive Delay Line. E. M. Bradburd. *Electrical Communication*, Vol. 28, No. 1, March, 1951, pp. 46–53, illus. 2 references. The fundamental design equations for the magnetostrictive delay lines are given together with methods for eliminating the damaging effects that might be caused by echoes from the ends of the line.

Mixer Harmonic Chart. Thomas T. Brown. *Electronics*, Vol. 24, No. 4, April, 1951, pp. 132, 134.

Chart speeds identification or prediction of spurious frequencies resulting from beating of various harmonic terms in mixer output when one input frequency is variable as in wide-band signals for TV, FM, and military communication.

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Correspondence: Definition of Information. Edgar Reich. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 3, March, 1951, p. 290. 6 references.

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The Development of V.H.F. Area Coverage Networks for Civil Aviation Communication. D. P. Taylor. *Electronic Engineering*, Vol. 23, No. 277, March, 1951, pp. 86–91, illus. 4 references. Network of VHF stations set up in 1947 by the British Ministry of Civil Aviation in Southern England.

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ELECTRONIC TUBES

Military Requirements for Subminiature Tubes. James D. Fahnestock. *Electronics*, Vol. 24, No. 4, April, 1951, pp. 108, 109, illus. Applications and types; development trends; inadequacies of current production output; expansion plans.

Boride Cathodes. J. M. Lafferty. *Journal of Applied Physics*, Vol. 22, No. 3, March, 1951, pp. 299–309, illus. 4 references.

Investigation of the thermionic emission properties of the borides of the alkaline-earth and rare-earth metals. These compounds can be used for cathodes for high-density applications. Chemical preparation, cathode preparation, and base materials are explained. The highest electron emission was obtained with lanthanum boride.

The Balitron Tube. II. Norman Z. Ballantyne. *Radio & Television News*, Vol. 45, No. 4 (*Radio-Electronic Engineering*, Vol. 16, No. 4), April, 1951, pp. 16A, 18A, 19A, 24A, 25A, illus. Basic advantages of the Balitron tube over conventional-type tubes; interelectrode capacity effects; by-passing considerations.

Tube Characteristic Tracer Using Pulse Techniques. Herbert M. Wagner. *Electronics*, Vol. 24, No. 4, April, 1951, pp. 110–114, illus. 9 references.

Electron-tube curve tracer designed at the Signal Corps Engineering Laboratories used pulse techniques to display, on a cathode-ray screen, tube characteristics up to high-peak power levels in the positive grid region. Each pulse produces a dot on the screen, the pulses combining to form the complete curve. Photographic apparatus is described for recording the family of curves. A circuit diagram shows all component values and power supplies.

MEASUREMENTS & TESTING

Procedure for Calibrating Collins 51R-1 Navigation and BC733D Localizer Receivers. Francis J. Gross and Max Kinkaid. *U.S., Civil Aeronautics Administration, Technical Development Report No. 122*, September, 1950. 16 pp., illus.

High Frequency Crystal Calibrator. Jerry B. Minter. *Radio & Television News*, Vol. 45, No. 4 (*Radio-Electronic Engineering*, Vol. 16, No. 4), April, 1951, pp. 6A, 26A, 27A, illus. Design information on an instrument for accurate frequency calibration in the range of 250 kc. to 1,000 mc.

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Triggered or free-running pulses and c-w signals are provided from 47 to 76 mc. for testing radar and other wide band i-f circuits. Output is variable from 0.1 microvolt to 0.1 volt with pulse widths of 0.25, 0.5, and 1 microsec.

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Specialized operational and accuracy requirements in D.M.E. performance in the terminal area. Details are given of a distance-measuring technique that is technically compatible with the azimuth system, permitting integration of equipment and use of the same radio channels.

Frequency Allocation for Aviation Electronics. Edwin Lee White. *Aeronautical Engineering Review*, Vol. 10, No. 5, May, 1951, pp. 38–41.

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Design of a Loran Transmitter. R. H. Myers. *Electrical Communication*, Vol. 28, No. 1, March, 1951, pp. 31–45, illus. 1 reference.

Design problems; actual design development of a transmitter that uses grid modulation in the penultimate stage to shape the transmitted pulse; power amplifier. Block and schematic diagrams show the electrical connections.

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Saturable Reactors and Control Oscillators. Ed. Bukstein. *Radio & Television News*, Vol. 45, No. 4, April, 1951, pp. 42, 120, 121, illus.

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TELEMETRY

Errors Introduced into F-M Carrier Measuring Systems by Time-Base Variations in Recording and Reproducing Data. James C. Coe. *Instruments*, Vol. 24, No. 3, March, 1951, pp. 274–278, illus. 1 reference.

Types of recording; instruments for recording; theoretical explanation of amplitude errors caused by time-base variations; evaluation of recording oscillographs and disc, cathode-ray, magnetic, and printing recorders.

Cosmic-Ray Radiosonde and Telemetering System. Martin A. Pomerantz. *Electronics*, Vol. 24, No. 4, April, 1951, pp. 88–92, illus. 4 references.

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Balloon-borne apparatus comprises several units that are constructed and tested separately. It operates as follows: Geiger-Müller counters trigger a multivibrator, which keys a UHF transmitter; received c-w pulses suppress superregenerative receiver hiss, and a signal converter operates a recording oscillograph. The weight of the unit is 10.3 lbs. (not including lead absorber and rigging).

TRANSMISSION LINES

Cut-Off Frequency in Two-Dielectric Layered Rectangular Wave Guides. J. Van Bladel and Thomas J. Higgins. *Journal of Applied Physics*, Vol. 22, No. 3, March, 1951, pp. 329–334, illus. 3 references.

A Note on Reflection and Transmission. Bela A. Lengyel. *Journal of Applied Physics*, Vol. 22, No. 3, March, 1951, pp. 263, 264. 3 references.

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Effects of the Atmospheric Scale Height Gradient on the Variation of Ionization and Short Wave Absorption. M. Nicolet. *Journal of Atmospheric and Terrestrial Physics*, Vol. 1, No. 3, 1951, pp. 141–146. 4 references.

The Cosmic Ray Intensity and Radio Fade-Outs. D. W. N. Dolbear, H. Elliot, and D. I. Dawton. *Journal of Atmospheric and Terrestrial Physics*, Vol. 1, No. 3, 1951, pp. 187, 188, illus. 6 references.

Equipment

Oil Filter Evaluation. Edward G. Fochtman and Louis E. Anderson. *The Frontier*, Vol. 14, No. 1, March, 1951, pp. 9–14, 23, illus. 8 references. Characteristics of an ideal filter; types; evaluation procedure and results of tests for Cuno Engrg. Corp.

ELECTRICAL (16)

Transient Analysis of Three-Phase Power Systems. I. Eric T. B. Gross and Leonard Rabins. *Franklin Institute, Journal*, Vol. 251, No. 3, March, 1951, pp. 333–341, illus. 26 references.

The application of symmetric components to the solution of steady-state problems in power-systems engineering suggests the application of the same or similar components in the study of transient phenomena on the network calculating board by means of an oscilloscope and synchronous switch. It is found upon rigorous examination that symmetric components are applicable to such problems in only a few types of switching.

Materials Engineering File Facts No. 206: Alternate and Substitute Materials for Electrical Equipment and Parts. *Materials & Methods*, Vol. 33, No. 3, March, 1951, p. 107.

HYDRAULIC (20)

Inverted Relief Valves in Aircraft. Howard F. Schmidt. *Applied Hydraulics*, Vol. 4, No. 3, March, 1951, pp. 44–46, 48, illus. Purposes for which relief valves are used; requirements for satisfactory performance; minimizing of valve chatter.

Pressure Pumps Proved in Use. *Aviation Week*, Vol. 54, No. 13, March 26, 1951, pp. 53, 54, 57, 59, 60, illus. Performance evaluation of the high-pressure gear-type hydraulic pumps built by Pesco Div., Borg-Warner Corp.; pump design; performance tables.

Displacement Versus Time Characteristics of Hydraulic Actuators. L. Sigfred Linderoth, Jr. *American Society of Mechanical Engineers, Transactions*, Vol. 73, No. 2, February, 1951, pp. 147–152, Discussion, pp. 152–154, illus.

Development of the relation between the displacement and time of a piston in a hydraulic actuator in terms of load, mass, pressure drop, viscosity, and special operating conditions, based on the Fanning law of friction in pipes as given by Hagen-Poiseuille and Blasius. The method is valid for pressures up to 100 atmospheres.

Hydraulic Serviceability. R. H. Bound and H. G. Conway. *Flight*, Vol. 59, No. 2200, March 23, 1951, pp. 344–346, illus. (Summary of an R.Ae.S. lecture, March 15, 1951: Progress Towards Hydraulic Serviceability.)

Flight Operating Problems (31)

ICE PREVENTION & REMOVAL

Airframe and Engine De-Icing. D. G. Thorpe. *The Technical Instructor*, Vol. 6, No. 2, February, 1951, pp. 3–8, illus.

A system of aircraft de-icing by heat. A gasoline-burning combustion heater is used to carry heat to the wing leading edges. The components and operation of the system are analyzed, including applications to engine and propeller de-icing.

Icing-Protection Requirements for Reciprocating-Engine Induction Systems. Willard D. Coles, Vern G. Rollin, and Donald R. Mulholland. *U.S., N.A.C.A., Report No. 982*, 1950. 24 pp., illus. 29 references. Superintendent of Documents, Washington. $0.20.

Experimental investigation of icing in reciprocating-engine induction systems; study of impact icing, throttling icing, and fuel-evaporation icing; ice formation on the components of the induction system; effects of engine size, operating variables, and fuel volatility; study of ice-detection systems and methods of preventing and removing induction-system ice.

PILOTING TECHNIQUE

Correspondence: Flight on Asymmetric Power. Eric L. Beverly. **Author's Reply.** E. Wright. *Aircraft Engineering*, Vol. 23, No. 265, March, 1951, p. 85.

WEATHER HAZARDS

Hailstone Impact Tests on Aircraft Structural Components. Pell Kangas. *U.S., Civil Aeronautics Administration, Technical Development Report No. 124*, September, 1950. 20 pp., illus. 2 references.

Test data from simulated hailstone tests on windshield materials, nonmetallic materials used in the construction of the radar housing, the nose of the airplane fuselage, the metallic leading edges of wings, and the propeller dome.

Flight Safety & Rescue (15)

Aviation Progress and Safety Should March Hand-in-Hand. Jerome Lederer. (*S.A.E., Annual Meeting, Detroit, January 8–12, 1951, Preprint No. 552.*) *U.S. Air Services*, Vol. 36, No. 3, March, 1951, pp. 16, 17.

Accident Investigation; How Causes Are Found and Cures Applied. Vernon Brown. *Flight*, Vol. 59, No. 2198, March 9, 1951, pp. 286, 287, illus. (Summary of a paper.)

I.C.A.O.'s New Performance Requirements. F. W. A. Patmore. *The Aeroplane*, Vol. 80, No. 2066, February 23, 1951, pp. 242–244, illus. I.C.A.O. airworthiness requirements; basis of British requirements.

Simple Stall Warning. *Flight*, Vol. 59, No. 2198, March 9, 1951, p. 280, illus. Design details of the Goodwin stall-warning device for light aircraft which requires no electrical supply.

Flight Testing (13)

Flight Research. I, II. Handel Davies. *Flight*, Vol. 59, Nos. 2196, 2197, February 23, March 2, 1951, pp. 212–214; 262–264; illus. (Summary of an R.Ae.S. lecture, February 15, 1951: Some Aspects of Flight Research.) Developments in flight research, concerned with aircraft drag reduction, stability and control problems, and general aerodynamics.

Some Aspects of Flight Research. Handel Davies. *The Aeroplane*, Vol. 80, No. 2167, March 2, 1951, pp. 267, 268, illus. (Summary of an R.Ae.S. lecture, February 15, 1951.)

Fuels & Lubricants (12)

Properties and Performance of Silicone Lubricants. G. Grant, 3rd, and C. C. Currie. *Mechanical Engineering*, Vol. 73, No. 4, April, 1951, pp. 311–316, illus. 8 references.

Physical characteristics, classified as to physical state, chemical structure, and type of thickening agent; results of tests on the silicone fluids and greases; performance evaluation with various types of bearings; applications. Tables indicate the properties, effectiveness, and relative life of silicone lubricants.

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- **Endurance Limit:** In rotating beam tests of polished specimens at room temperature and 10,000 rpm for 10^8 cycles, Duranickel hot-rolled showed an endurance limit of 51,000 psi.; hot-rolled, age-hardened showed 52,500 psi.; cold-drawn 51,000 psi.; and cold-drawn, age-hardened showed 61,000 psi.

- **Impact Strength:** Charpy impact strength ranges from 240 ft. lb. for hot-rolled Duranickel and 190 ft. lb. for cold-drawn, to 40 ft. lb., for the age-hardened condition.

- **Spring Properties:** Duranickel wire can be cold-drawn and age-hardened subsequently to develop tensile strength of the order of 225,000 psi. The torsional proportional limit of cold-drawn and age-hardened wire is about 40 per cent of the ultimate tensile strength. Duranickel springs are used at temperatures up to 550°F.; the stresses used should be governed by existing service conditions.

- **Working Characteristics:** Duranickel may be hot-worked, forged, and cold-worked. It can be machined most readily in the annealed condition and is commercially machinable in other conditions at hardnesses up to 275 BHN. The use of a cutting lubricant is essential for all machining work because Duranickel, like all high-nickel alloys, is characteristically "sticky" and tends to gall or build up on the tools. Duranickel can be joined by the usual welding, brazing and soft soldering processes common to industry.

- **Variants:** For special uses there are two alloys similar to Duranickel. They are: (1) Duranickel "R" containing a higher percentage of carbon for use where applications require optimum machinability. (2) Permanickel® having the same mechanical properties as Duranickel but different physical constants, particularly better electrical and thermal conductivity and stronger magnetic properties. Permanickel is preferred for service as springs requiring high electrical conductivity; equipment requiring good thermal conductivity and magnetostrictive units where high fatigue strength is required. Special applications include thermostat tension springs, reaction springs, clips, grid wires and side rods in vacuum tubes.

- **Corrosion Resistance:** The corrosion resistance of Duranickel in all its forms is of the same order as that of nickel to a wide variety of media, including mineral and organic acids, alkalies, salts, potable and industrial waters, food products, organic compounds and oxidizing atmospheres at normal and elevated temperatures.

- **Forms Produced:** Duranickel is supplied in most commonly used mill forms—rods, hexagons, squares, rounds, flats, strip, sheet, wire and welding materials.

- **Applications:** Duranickel is used in many applications where corrosion resistance, high hardness, and great strength are required. In the production of plastics, Duranickel is a standard material for dies, injection cylinders and extrusion screws. Duranickel springs, from both wire and strip, give excellent service. Instrument parts include diaphragms, bellows, flapper valve discs, snap switch blades, and grid wires and side rods in vacuum tubes.

Mechanical Property Ranges of Duranickel

Form and Condition	Tensile Strength 1000 psi.	Yield Strength (0.2% offset) 1000 psi.	Elongation in 2 in. per cent	Hardness Rockwell C
Rod and Bar				
Hot-finished	90-130	35-90	55-30	75B-22
Hot-finished, age-hardened	160-200	115-150	30-15	32-42
Cold-drawn, as-drawn	110-150	60-130	35-15	90B-32
Cold-drawn, age-hardened	170-210	125-175	25-15	32-42
Strip				
½ hard	130-155	.....	15-3	25-34
½ hard, age-hardened	170-210	.....	20-7	33-42
Spring	155-190	.....	10-2	30-40
Spring, age-hardened	180-230	.....	15-5	36-46
Wire				
Spring	160-200	.....	5-2	....
Spring, age-hardened	200-240	.....	10-5	....

FURTHER DATA AVAILABLE

A 22-page reference manual, *Engineering Properties of Duranickel*, Technical Bulletin T-32, contains all essential engineering information. It is available, free, for your files. For help on specific metal problems, write directly to Inco's Technical Service, outlining your problems.

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A Mechanical Wear Test Using Fission Fragments. David H. Frisch and Jules S. Levin. *American Society for Testing Materials, Bulletin*, No. 172, February, 1951, pp. 64, 65, illus. 2 references.

Airline Experience with Aircraft Engine Lubricating Oils. Harry N. Taylor. *S.A.E., National Aeronautic Meeting, New York, April 16–19, 1951, Preprint No. 620.* 17 pp., illus. 1 reference. $0.25.

Gliders (35)

Progress Report on the Sailplane Projects of the Engineering Research Station of Mississippi State College. August Raspet. *Soaring*, Vol. 15, No. 1, January-February, 1951, pp. 6, 7.

Sailplane Under the Magnifying Glass. Gerhard Blessing. *Sailplane and Glider*, Vol. 19, No. 3, March, 1951, pp. 52, 53, 56, illus. Design of a sailplane in which the cockpit becomes a motor scooter, the wings fold back, and the tail folds down for ground transporting.

Guided Missiles (1)

Guided Missiles in Modern Warfare; The Potentialities of a New Weapon. Nels A. Parson, Jr. *Ordnance*, Vol. 35, No. 185, March-April, 1951, pp. 403–405, illus.

Instruments (9)

Further Experiments on the Flow and Heat Transfer in a Heated Turbulent Air Jet. Stanley Corrsin and Mahinder S. Uberoi. *U.S., N.A.C.A., Report No. 998*, 1950. 17 pp., illus. 24 references. Superintendent of Documents, Washington. $0.20.

A hot-wire technique for simultaneously measuring temperature and velocity fluctuations in turbulent shear flow. The instruments used are a hypodermic-needle total-head tube, a Chromel-Alumel thermocouple, and a hot-wire anemometer of 0.00025-in. platinum etched from Wollaston wire. Mean total head and mean temperature are simultaneously recorded photographically, using an automatic traversing arrangement with the total-head tube and thermocouple. Measuring procedures are explained, and the technique is applied to a heated turbulent air jet.

A Theoretical Method of Determining the Control Gearing and Time Lag Necessary for a Specified Damping of an Aircraft Equipped with a Constant-Time-Lag Autopilot. Ordway B. Gates, Jr., and Albert A. Schy. *U.S., N.A.C.A., Technical Note No. 2307*, March, 1951. 38 pp., illus. 7 references.

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Simple Stall Warning. *Flight*, Vol. 59, No. 2198, March 9, 1951, p. 280, illus.

A simple stall-warning device—a patent application of C. P. Goodwin, Cornwall, England—requires no electrical supply. The instrument has a hinged flap that is kept closed at normal air speeds; if the speed drops below the critical speed, the flap opens and, through an arrangement of tubes, a whistle sounds, warning of stall. Reattainment of normal air speed closes the flap and stops the whistle.

The Mass Flow Meter; A Method for Measuring Pulsating Flow. D. Brand and L. A. Ginsel. *Instruments*, Vol. 24, No. 3, March, 1951, pp. 331–335, illus. 3 references.

The Use of an Uncalibrated Cone for Determination of Flow Angles and Mach Numbers at Supersonic Speeds. Morton Cooper and Robert A. Webster. *U.S., N.A.C.A., Technical Note No. 2190*, March, 1951, 30 pp., illus. 20 references.

A pressure-distribution investigation of a body of revolution in the Langley 4- by 4-ft. supersonic tunnel at $M = 1.59$ and $R = 1.04 \times 10^6$ per ft. The data over the forward part of the body have been analyzed to indicate the accuracy with which an uncalibrated cone containing four static-pressure orifices and one total-pressure orifice can be used as a Mach Number and flow-angle indicator at supersonic speeds.

Flight Investigation of the Variation of Static-Pressure Error of a Static-Pressure-Tube with Distance Ahead of a Wing and a

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Fuselage. William Gracey and Elwood F. Scheithauer. *U.S., N.A.C.A., Technical Note No. 2311*, March, 1951, 26 pp., illus. 4 references.

Flight calibrations of the static pressure error of a static-pressure tube located 1/4 to 2 chords ahead of the wing tip of a trainer airplane and 1/2 to 1 1/2 body diameters ahead of the fuselage and 1 chord ahead of the wing tip of a fighter airplane. Calibrations were obtained over an indicated speed range from stall to speeds not exceeding 265 m.p.h.

Readers' Forum: A Probe for Measuring Flow Inclination in a Supersonic Air Stream. Robert D. Fusfeld. *Journal of the Aeronautical Sciences*, Vol. 18, No. 5, May, 1951, p. 356, illus. The probe is a form of blunt body; it consists of four small-diameter tubes soldered together with the leading edges cut off to form a conical nose shape.

New Equipment for Single-Frame Photo-Recording. *Oscillographer*, Vol. 12, No. 3, July–September, 1950, pp. 2–12, illus. Operation, specifications, and components of DuMont Oscillograph-Record cameras.

A Rotary Chart Translator. G. A. Flint and J. G. Lee. *The Engineer*, Vol. 191, No. 4964, March 16, 1951, pp. 340–342, illus.

Rotary charts can be replotted automatically onto a continuous time base (strip chart) by a translator developed at the British Iron and Steel Research Assn. A plan shows the general arrangement of the translator. The instrument has an accuracy of approximately ±3 per cent.

Effect of Amplitude of Apparent Vibration, Brightness, and Type Size on Numeral Reading. M. N. Crook, G. S. Harker, A. C. Hoffman, and J. L. Kennedy. (Tufts College, Institute for Applied Experimental Psychology.) *U.S., Air Force, Technical Report No. 6246*, September, 1950. 54 pp., illus. 14 references.

Correspondence: Ascertaining the Critical Servo Gain. Arthur Schland. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 3, March, 1951, p. 290. 1 reference.

Experimental Frequency Analysis of Servo Elements. A. Garde and E. Persson. *ASEA Journal*, Vol. 23, No. 12, December, 1950, pp. 163–166, illus. 2 references. A method for measuring the transfer function for single control elements or control loops.

Servomechanisms with Linearly Varying Elements. M. J. Kirby. *Electrical Engineering*, Vol. 70, No. 4, April, 1951, p. 343. 1 reference. (Digest of a paper.)

Fatigue Testing Machine for Applying a Sequence of Loads of Two Amplitudes. Frank C. Smith, Darnley M. Howard, Ira Smith, and Richard Harwell. *U.S., N.A.C.A., Technical Note No. 2327*, March, 1951. 31 pp., illus. 17 references.

Construction, operation, and calibration of two identical fatigue-testing machines. The machines can automatically subject sheet-metal specimens to a prescribed number of cycles of axial-fatigue load, changing the load amplitude for another number of cycles, and repeating the procedure until failure occurs. Pulsating and completely reversed axial loads can be applied; maximum loading is 2,000 lbs.

A Simplified Thermocouple for Temperature Measurements in High Velocity Gas Streams. H. M. Beede and C. R. Droms. (*Instrument Society of America, Conference, Buffalo, September 18–20, 1950, Paper No. 50-13-3.*) *Instruments*, Vol. 24, No. 3, March, 1951, pp. 338–341, illus.

Vibration Test Equipment for Turbine Blades. A. M. Roberts and A. A. Gregory. *The Engineer*, Vol. 191, No. 4965, March 23, 1951, pp. 370–372, illus.

The apparatus consists of a vacuum-tube oscillator coupled to a double-beam oscillograph and its amplifiers and the blade holder, which is mounted on a cast-iron base carrying the exciter magnet with a crystal microphone pickup and an external resonance indicator. A block diagram indicates the arrangement of the components. A graphite pencil point scans the blade surface, marking the nodal lines.

Laws & Regulations (44)

The Legal Status of Executive Agreements on Air Transportation. II. Oliver J. Lissitzyn. *Journal of Air Law and Commerce*, Vol. 18, No. 1, Winter, 1951, pp. 12–32. 40 references.

Mexico Draft Convention on Damage Caused by Foreign Aircraft to Third Parties on the Surface. *Journal of Air Law and Commerce*, Vol. 18, No. 1, Winter, 1951, pp. 98–108.

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Dry Metallic Friction As a Function of Temperature Between 4.2°K. and 600°K. I. Šimon, H. O. McMahon, and R. J. Bowen. *Journal of Applied Physics*, Vol. 22, No. 2, February, 1951, pp. 177–184, illus. 10 references.

Measurements of the friction coefficients and mechanical properties of Fe, Ni, Cu, Pb, Sn, and Zn to study the problem of friction between two unlubricated surfaces of the same metal; evaluation of the nature of dry friction.

GEARS & CAMS

Selection of Gear Materials. C. R. Austin. *Machine Design*, Vol. 23, No. 3, March, 1951, pp. 157–160, illus. Results of some studies of gear-tooth surface stresses under specified contact conditions based on investigations of Meehanite metal.

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Cam Dynamics. Alfred S. Gutman. *Machine Design*, Vol. 23, No. 3, March, 1951, pp. 149–151, 202, 203, illus. 4 references. Dimensionless analysis of cam dynamics using the rate of change of acceleration as the index of dynamic characteristics.

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Electrical Analogy Determination of Torsional Vibration Frequencies of Shaft Systems. M. Ballet. (*Revue Générale de Mécanique*, Vol. 34, No. 24, December, 1950, pp. 429–434.) *Engineers' Digest*, Vol. 12, No. 3, March, 1951, pp. 96–98, illus. 5 references.

Evaluation of the electrical analogy method and of four analogies used for torsionally vibrating systems; test methods and equipment that represent the mechanical system; applications.

The Electronic Dynamic Balancing Machine. S. A. Rybczynski. *Electronics Forum*, No. 19, September, 1950, pp. 18–31, illus.

The Dawes Instruments Dynamic Balancing Machine, Type 1250, is a bench instrument designed for general mass production testing of small rotor units and armatures; it quickly and accurately determines the position and amount of unbalance. Theory (static and dynamic unbalance and balance in two planes), design, setting-up procedure, and operation of the instrument are explained.

Discussion: Torsion of Noncylindrical Shafts of Circular Cross-Section, by H. J. Reissner and G. J. Wennagel. H. Poritsky. **Authors' Closure.** *Journal of Applied Mechanics*, Vol. 18, No. 1, March, 1951, pp. 122, 123. 3 references.

Critical Velocities of Ultracentrifuges. V. I. Sokolov. (*Zhurnal Tekhnicheskoi Fiziki*, U.S.S.R., Vol. 14, No. 4, 1946, pp. 463–468.) *U.S., N.A.C.A., Technical Memorandum No. 1272*, March, 1951. 11 pp., illus. 2 references. Analysis of the characteristics of critical velocities of ultracentrifuges using the Euler differential equations of rotations of a solid body; practical applications.

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Simplified Helical Spring Design. Carl Thumin and Hubert A. Riester. *Product Engineering*, Vol. 22, No. 3, March, 1951, pp. 136–140, illus., fold chart. With spring selection charts for oil-tempered spring steel and music wire.

The Design of Nonlinear Leaf Springs. S. P. Clurman. *American Society of Mechanical Engineers, Transactions*, Vol. 73, No. 2, February, 1951, pp. 155–161, illus.

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functions having increasing first derivatives. The accuracy of theoretical derivations decreases with increasing deflections; the solutions are approximations unverified by experimentation.

TRANSMISSIONS, CLUTCHES, & DRIVES

The Magnetic Fluid Clutch. S. F. Blunden. *The Engineer*, Vol. 191, No. 4961, February 23, 1951, pp. 244, 245, illus. Design and construction of a magnetic fluid clutch made at the Ministry of Supply Radar Research and Development Establishment; test results; design evaluation.

Maintenance (25)

Planned Maintenance. D. O. MacDougall. *Shell Aviation News*, No. 152, February, 1951, pp. 18–23, illus. B.O.A.C. maintenance and repair procedure; salvaging of parts.

Materials (8)

Fatigue Testing Machine for Applying a Sequence of Loads of Two Amplitudes. Frank C. Smith, Darnley M. Howard, Ira Smith, and Richard Harwell. *U.S., N.A.C.A., Technical Note No. 2327*, March, 1951. 31 pp., illus. 17 references.

Construction, operation, and calibration of two identical fatigue-testing machines for studying the effects of a wide range of stress-cycle combinations on the fatigue-strengths of sheet materials. The machine can test specimens of sheet materials with maximum dimensions of 2- by 6- by 0.1-in., up to a maximum load of 2,000 lbs., with an accuracy of ±3 per cent.

Discussion: The Flow and Fracture of a Brittle Material, by L. F. Coffin, Jr. I. Cornet, R. C. Grassi, C. W. MacGregor, and E. B. Shand. **Authors' Closure.** *Journal of Applied Mechanics*, Vol. 18, No. 1, March, 1951, pp. 120–122, illus. 6 references.

CERAMICS & CERAMALS

Ceramics—A Survey of Their Possibilities As Gas-Turbine Blade Materials. T. G. Carruthers and A. L. Roberts. *Aircraft Production*, Vol. 13, No. 149, March, 1951, pp. 88–91, tables. 25 references.

Investigation of multicomponent materials forming eutectics of very high melting point and single-component high-melting-point materials giving theoretically no liquid below the melting point of the component itself; evaluation as gas-turbine materials; suggested improvements.

A Theory of the Envelope Type of Thermal Conductivity Tests. Arthur L. Loeb. *Journal of Applied Physics*, Vol. 22, No. 3, March, 1951, pp. 282–284, illus.

Measurement of the thermal conductivity of ceramic materials at a high temperature. A uniformly heated spherical core (rather than cylindrical) is surrounded by a hollow sphere of the ceramic. The heat-flow equations are derived to obtain the conductivity from the average temperature gradient across the ceramic.

New Zirconia Refractory Material Useful at Temperatures to 4600°F. *Materials & Methods*, Vol. 33, No. 3, March, 1951, p. 81, illus.

Heat Resistant Ceramic Coatings Permit Substitutes for Critical Materials. Dwight G. Bennett. *Materials & Methods*, Vol. 33, No. 3, March, 1951, pp. 65–67, illus.

METALS & ALLOYS

A Dynamic Method for Measuring the Specific Heat of Metals. Alan M. Nathan. *Journal of Applied Physics*, Vol. 22, No. 2, February, 1951, pp. 234, 235, illus.

Study of the specific heat curves of low-carbon steel at the phase transformation points by a dynamic method. An electrical apparatus is used to obtain a curve of temperature vs. time, in which any sharp changes in the slope of the curve indicate changes in the specific heat at that temperature. By measuring the temperature at which the breaks in the curve occur, the occurrence and location of specific heat changes can be read during rapid heating and extremely slow or equilibrium conditions.

A Mechanical Determination of Biaxial Residual Stress in Sheet Materials. R. G. Treuting and W. T. Read, Jr. *Journal of Applied Physics*, Vol. 22, No. 2, February, 1951, pp. 130–134, illus. 6 references.

Two principal components of stress are explicitly expressed as functions of curvature. This eliminates the need for calculation by successive approximations. The method involves the removal of successive uniform layers from the surface of a sample. The sample considered must be linear in pure bending; the stress varies only through the thickness, and the removal of surface layers does not vary the stress in the remaining sample.

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Experimental, preliminary investigation of the mechanism of fracture in simple tension on specimens of refined zinc at room temperature and up to 300°C. and on specimens of commercial zinc at room temperature. Local plastic deformation was studied in the stressing, to rupture, of mild steel.

A Survey of Low-Temperature Properties of Metals. E. J. Ripling. (*Iron Age*, Vol. 166, Nos. 16, 17, October 19, 26, 1951, pp. 76–80; 53–57.) *Engineers' Digest*, Vol. 12, No. 2, February, 1951, pp. 49–52, illus. 7 references. Characteristics of martensitic, pearlitic, and annealed steels at temperatures down to —400°F.

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Fatigue Failures Are Tensile Failures; Prestressing Processes and Fracture Barriers. J. O. Almen. *Product Engineering*, Vol. 22, No. 3, March, 1951, pp. 101–124, illus. 17 references.

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Impact Tests Help Engineers Specify Steel. L. D. Jaffe, P. R. Kosting, A. F. Jones, J. I. Bluhm, A. Hurlich, and J. F. Wallace. *SAE Journal*, Vol. 59, No. 3, March, 1951, pp. 24–28, illus. (Based on papers given at a meeting of the Iron and Steel Technical Committee's Division XXIV, "Low-Temperature Properties of Ferrous Materials.")

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The Yield Point of Mild Steel at Non-Homogeneous and Compound Stress Distributions. Folke K. G. Odqvist and Cyrill Schaub. (*Kunglika Tekniska Högskola, Handlingar Nr. 34*, 1950.) *Acta Polytechnica* (Stockholm), No. 66 (*Mechanical Engineering Series*, Vol. 1, No. 11), 1950. 16 pp., illus. 13 references. Sw. Kr. 2:00. In English.

A new theory of the yield point involves a material constant, a, which is obtained by macroscopic measurements or X-ray measurements of the stress distribution immediately preceding the spreading of the flow layers. The apparent yield point is related to the spreading of the flow layers through the test section.

Effects of Some Solution Treatments Followed by an Aging Treatment on the Life of Small Cast Gas-Turbine Blades of a Cobalt-Chromium-Base Alloy. I—Effect of Solution-Treating Temperature. C. Yaker and C. A. Hoffman. *U.S., N.A.C.A., Technical Note No. 2320*, March, 1951. 37 pp., illus. 8 references.

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Creep of Lead at Various Temperatures. Peter W. Neurath and J. S. Koehler. *U.S., N.A.C.A., Technical Note No. 2322*, March, 1951. 32 pp., illus. Tables and curves give results of creep tests on lead, copper, and zinc in a temperature range of —190°C. to +30°C.

The Effect of Grain Direction on Mechanical Properties of Light Alloy Extrusions; A Report on a Series of Tests Carried Out by Vickers-Armstrongs at Weybridge. D. M. McElhinney. *Aircraft Engineering*, Vol. 23, No. 265, March, 1951, pp. 62–66, illus.

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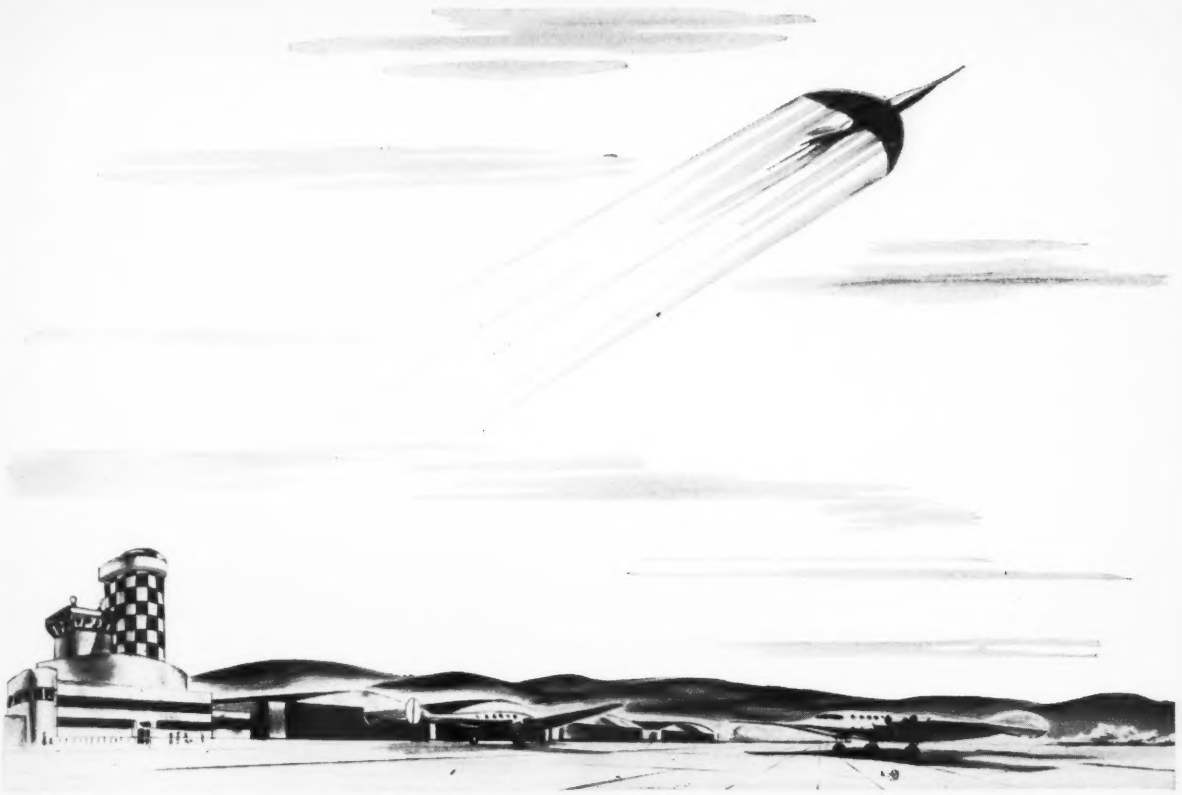

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London, on February 21 and 22, 1951. *Aircraft Engineering*, Vol. 23, No. 265, pp. 78–82, illus.

NONMETALLIC MATERIALS

Comparative Strengths of Some Adhesive-Adherend Systems. N. J. DeLollis, Nancy Rucker, and J. E. Weir. *American Society of Mechanical Engineers, Transactions*, Vol. 73, No. 2, February, 1951, pp. 183–193, illus. 17 references.

Investigation of double-lap shear, tensile, long-time-loading shear, and impact strengths of polyvinyl acetate, cellulose nitrate, resorcinol resin, casein, gum arabic, natural rubber, and neoprene adhesives with the following adherends: stainless steel, aluminum alloy, paper-phenolic laminate, glass, birchwood, and hard rubber.

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British Metals Adhesive Uses. C. J. Moss. *Aviation Week*, Vol. 54, No. 10, March 5, 1951, pp. 30, 32–35, 37, illus. British developments in adhesives for metal-to-metal bonding.

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Laminates; Fiberglas—Plastic Parts Have Many Ballistic and Dielectric Uses. Robert Temple. *Aviation Week*, Vol. 54, No. 12, March 19, 1951, pp. 43, 44, 47.

A Test Method for Determining Fogging Properties of Organic Materials. Vincent J. Marchese and Stanley J. Klima. *American Society for Testing Materials, Bulletin*, No. 172, February, 1951, pp. 40–43, illus. 6 references.

Test procedure and apparatus for determining characteristics of fogging produced by condensable vapors driven off from organic materials under conditions of high ambient temperature. A technique was developed to give a permanent photographic record of the fog deposit.

Effect of Strain Rate on the Tensile and Compressive Stress-Strain Properties of Polystyrene. C. C. Hsiao and J. A. Sauer. *American Society for Testing Materials, Bulletin*, No. 172, February, 1951, pp. 29–35, illus. 13 references.

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Analysis of the Elastic and Plastic Stability of Sandwich Plates by the Method of Split Rigidities. I. P. P. Bijlaard. *Journal of the Aeronautical Sciences*, Vol. 18, No. 5, May, 1951, pp. 339–349, illus. 20 references. Derivation of the general equation for the critical thrust for antisymmetric buckling of sandwich plates.

Meteorology (30)

Meteorological Analysis of Icing Conditions Encountered in Low-Altitude Stratiform Clouds. Dwight B. Kline and Joseph A. Walker. *U.S., N.A.C.A., Technical Note No. 2306*, March, 1951. 27 pp., illus. 12 references.

Liquid-water content, droplet size, and temperature data measured during 22 flights in stratiform clouds; analysis of meteorological conditions existing during 74 flights over four winters of average icing conditions.

Distance over Which an Aircraft Flying on a Constant Heading May Experience Severe Icing in Convective Cloud. R. F. Jones and J. G. D. Beimers. *Meteorological Magazine*, Vol. 80, No. 943, January, 1951, pp. 4–9, illus. 3 references.

An analysis of radar P.P.I. display-tube photographs taken on showery days. Ten-cm. radar equipment was used to receive radar echoes from precipitating cumulus and cumulo-nimbus clouds. The width of an echo on the P.P.I. scope along a certain bearing represents the distance over which an aircraft, flying on this bearing above the freezing level and below the echo top, would be exposed to severe icing risks.

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The Earth's Atmosphere. J. Humphries. *British Interplanetary Society, Journal*, Vol. 10, No. 1, January, 1951, pp. 18–26, illus. 4 references.

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The "Thunderstorm-Project" Data. Louis J. Battan. *American Meteorological Society, Bulletin*, Vol. 32, No. 1, January, 1951, pp. 27–29, illus. 2 references.

Effect of Quadric Terms in Differential Equations of Atmospheric Oscillations. C. L. Pekeris. *U.S., N.A.C.A., Technical Note No. 2314*, March, 1951. 10 pp., illus. 3 references.

Determination of the order of magnitude of the quadratic velocity terms that are neglected in linearized theory. It is shown that the linearized theory of atmospheric oscillations ceases to be valid at elevations greater than 80 to 100 km. since the quadratic velocity terms cannot be neglected. The possible effects of the neglected quadratic terms in the tidal equations on the resonance theory of atmospheric tides are qualitatively discussed.

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A Sensitive Vapour Pressure Recorder. W. C. Swinbank. *Journal of Scientific Instruments*, Vol. 28, No. 3, March, 1951, pp. 86–89, illus. 6 references.

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A New Recording Raingauge. A. Hauer. *Journal of Scientific Instruments*, Vol. 28, No. 3, March, 1951, pp. 84, 85, illus. 2 references.

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It Isn't the Heat—It's the Humidity. Charles A. Mabey. *Instruments*, Vol. 24, No. 3, March, 1951, pp. 280–283, 324, illus. 4 references. Brief history of hygrometry; descriptions of instruments for measuring humidity.

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Analysis of tables that show fog conditions at London Airport from August, 1946, to July, 1950. The tables, compiled from hourly visibility reports, are a record of the occasions when the visibility was less than 220, 440, 880, and 1,100 yards.

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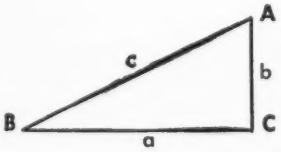

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Nomenclature of the Upper Atmosphere. N. C. Gerson and J. Kaplan. *Journal of Atmospheric and Terrestrial Physics*, Vol. 1, No. 3, 1951, p. 200. 1 reference.

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Navigation (29)

Distance-Measuring Equipment for the Terminal Area. Joseph Lyman and George B. Litchford. *Aeronautical Engineering Review*, Vol. 10, No. 5, May, 1951, pp. 48–55, illus. 2 references.

Relationship of electronics to air-traffic control; review of the problem of air-traffic control; specialized D.M.E. requirements in the terminal area; design of D.M.E. to meet these requirements.

All-Weather Flying; Impression of the All-Weather Flying Symposium, Electronics—2 Session, I.A.S. Nineteenth Annual Meeting. R. C. Robson. *Aeronautical Engineering Review*, Vol. 10, No. 5, May, 1951, pp. 44–47, 173, illus.

New Monitor. *Aviation Week*, Vol. 54, No. 13, March 26, 1951, pp. 48, 50, 51, illus.

An automatic traffic-control monitor, developed by Gilfillan Bros., Inc. When used in conjunction with Precision Approach Radar Model PAR-1, the monitor automatically keeps track of three aircraft simultaneously from touch-down to 10 miles to touch-down. Operating details and some specifications are given.

Air Traffic Control. Delos W. Rentzel. *Aeronautical Engineering Review*, Vol. 10, No. 5, May, 1951, pp. 18–21, 41, illus. Brief review of work of the Air Coordinating Committee toward setting up an efficient air-traffic-control system.

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Proposals for a New Air Navigation Chart. T. St. B. Freer and K. J. Irwin. *Institute of Navigation, Journal*, Vol. 4, No. 1, January, 1951, pp. 66–77, Discussion, pp. 77–80, illus.

Ordnance & Armament (22)

Aviation Engineering of Atomic Weapons. Richard G. Worcester. *American Aviation*, Vol. 14, No. 35, March 19, 1951, pp. 24–27, illus. Outline of the aviation problems involved in handling and delivering atomic fission and fusion weapons; reflector problems; radiation hazards; tactical weapons.

Harvard 2 (Noorduyn) Standard and Armament Trainer. II—Armament Installations. G. T. Johnson and J. G. Begg. *Canada, Royal Canadian Air Force, Experimental and Proving Establishment, Rockcliffe, Report No. 943 (Final Development Report No. D/154-2)*, January, 1951. 23 pp., illus.

Photography (26)

Use of Image Converter Tube for High-Speed Shutter Action. A. W. Hogan. *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 3, March, 1951, pp. 268–270, illus.

Images of objects illuminated by a continuous light source are impressed on the photocathode of an image-converter tube (1P25). The tube is pulsed electrically for the desired exposure period, such as 2 microseconds, and the resulting fluorescent image is viewed or photographed. Single-shot exposures, motion pictures, or stroboscopic photographs may be obtained.

A New Flash Illumination Unit for Ballistic Photography. H. F. Quinn and O. J. Bourque. *Review of Scientific Instruments*, Vol. 22, No. 1, February, 1951, pp.101–105, illus. 12 references.

Discussion of auxiliary electrical circuits in which two or more standard commercial flash tubes may be arranged in the same circuit to give higher flash intensities than can be obtained with a single tube.

New Equipment for Single-Frame Photo-Recording. *Oscillographer*, Vol. 12, No. 3, July–September, 1950, pp. 2–12, illus. Operation, specifications, and components of DuMont Oscillograph-Record cameras.

Electronic Flash Enlarger. William J. Moore, Jr., and William Martin. *Photographic Engineering*, Vol. 2, No. 1, January, 1951, pp. 10–19, illus.

Contribution to Theory of Errors for Double Point Intersection in Space. Bertil Hallert. (*Kunglika Tekniska Högskola, Handlingar Nr. 35*, 1950.) *Acta Polytechnica* (Stockholm), No. 67 (*Physics and Applied Mathematics Series*, Vol. 1, No. 8), 1950. 80 pp., illus. 16 references. Sw. Kr. 5:00. In English.

Review of the fundamental principle and practical application of double point intersection; method of least squares and its application to double-point intersection in space; mean error of standard observation in adjustment of vertical parallaxes; weight distribution.

Camera Sees Like Moving Eye. *Aviation Week*, Vol. 54, No. 13, March 26, 1951, pp. 32, 34, 36, illus.

The Transverse Panoramic Camera, developed by Perkin-Elmer Corp., uses only one roll of film and has a scanning prism that reflects the terrain into the fixed camera lens, producing a long narrow picture that shows terrain through an angle of 20° fore and aft and 180° laterally.

Autofocuser for Variable Focal Lengths. Gerhard Schwesinger. *Photographic Engineering*, Vol. 2, No. 1, January, 1951, pp. 20–25, illus. 2 references.

Power Plants

Power Versus Weight in Aviation. Maurice Roy. *The Aeroplane*, Vol. 80, No. 2167, March 2, 1951, pp. 264–266, illus. (Summary of the Louis Blériot Lecture, R.Ae.S., February 23, 1951.)

JET & TURBINE (5)

The Relative Merits of Centrifugal and Axial Compressors for Aircraft Gas Turbines. The Centrifugal Compressor. E. S. Moult and J. L. Brodie. **The Axial Compressor.** H. Pearson and A. C. Lovesay. *Royal Aeronautical Society, Journal*, Vol. 55, No. 483, March, 1951, pp. 129–145, Discussion, pp. 145–152, illus.

The Aviation Engine. I, II. F. R. Banks. (James Clayton Lecture, Institution of Mechanical Engineers, February 16, 1951.) *The Engineer*, Vol. 191, Nos. 4961, 4962, February 23, March 2, 1951, pp. 259, 260; 278–280; illus. The aviation gas-turbine engine: chronology, types, economics, fuel consumption, axial or centrifugal compressor, efficiency, maintenance, effects on aircraft design.

Power Plant Development over Twenty Years. F. R. Banks. *The Aeroplane*, Vol. 80, No. 2167, March 2, 1951, pp. 260, 261, illus. (Summary of the James Clayton Lecture, Institution of Mechanical Engineers, February 16, 1951: The Aviation Engine.)

The French Jet Engine Industry. Paul H. Wilkinson. *Aviation Age*, Vol. 15, No. 3, March, 1951, pp. 34, 35, illus.

Analysis of Spanwise Temperature Distribution in Three Types of Air-Cooled Turbine Blade. John N. B. Livingood and W. Byron Brown. *U.S., N.A.C.A., Report No. 994*, 1950. 18 pp., illus. 6 references. Superintendent of Documents, Washington. $0.20.

Derivation of an equation for calculating the spanwise temperature distribution in an air-cooled hollow turbine blade, a hollow blade with an insert, and a hollow blade with cooling fins, including the effects of heat transfer by convection, conduction, and radiation, and the heat of compression. Simplified forms of the equation are also developed.

J-35 (Allison Turbojet) Points Up New Thrust Achievements. Irving Stone. *Aviation Week*, Vol. 54, No. 14, April 2, 1951, pp. 25, 26, 29, illus.

Aspin 1; Turbomeca Jet Unit with Variable Augmentation by Ducted Fan. *Flight*, Vol. 59, No. 2193, February 1, 1951, pp. 135, 136, illus.

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Hycar seal developed and made by Parker, Stearns & Co., Brooklyn, N. Y. Photo courtesy of Republic Aviation Corp., Farmingdale, Long Island, N. Y.

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Four Turboprop Configurations—How They Compare. Tibor F. Nagey. *SAE Journal*, Vol. 59, No. 3, March, 1951, pp. 22, 23, illus. (Excerpts from a paper: Comparison of Turbine-Propeller Engines with Various Cycle Arrangements for Subsonic Flight Speeds.)

Effect of Heat and Power Extraction on Turbojet-Engine Performance. IV—Analytical Determination of Effects of Hot-Gas Bleed. Stanley L. Koutz. *U.S., N.A.C.A., Technical Note No. 2304*, March, 1951. 43 pp., illus. 3 references. Generalized working charts for obtaining the performance of a turbojet engine with tailpipe gas bleed.

Turbine-Blade Inspection; Application of the Sheffield Precisionnaire Pneumatic-Unit Gauging System. *Aircraft Production*, Vol. 13, No. 150, April, 1951, pp. 105, 106, illus.

The blade profile is checked at three points on the convex side, at three on the concave side, and at three stations along the blade by standard gaging elements (Plunjets); the system is based on the use of an air-supply at standardized pressure.

Effects of Some Solution Treatments Followed by an Aging Treatment on the Life of Small Cast Gas-Turbine Blades of a Cobalt-Chromium-Base Alloy. I—Effect of Solution-Treating Temperature. C. Yaker and C. A. Hoffman. *U.S., N.A.C.A., Technical Note No. 2320*, March, 1951. 37 pp., illus. 8 references.

Experiments to determine the effects of solution treating at 2,350°, 2,250°, and 2,100°F., followed by aging at 1,500°F., on the life of small cast AMS 5385 gas-turbine blades. The blades were operated in a small gas turbine 11 in. in diameter (9.5-in. disc diameter). Resulting blade temperature was approximately 1,500°F., and the blades were subjected to centrifugal stress at the mid-span of 20,000 lbs. per sq.in.

Vibration Test Equipment for Turbine Blades. A. M. Roberts and A. A. Gregory. *The Engineer*, Vol. 191, No. 4965, March 23, 1951, pp. 370–372, illus.

Design, operation, and performance of an apparatus for the determination of critical frequencies and modes of vibration. The nodal patterns of the blade can be traced for each resonant condition.

Analytical and Experimental Investigation of Effect of Twist on Vibrations of Cantilever Beams. Alexander Mendelson and Selwyn Gendler. *U.S., N.A.C.A., Technical Note No. 2300*, March, 1951. 48 pp., illus. 12 references.

A study of vibrations and the determination of natural modes and frequencies of turbine and compressor blades, in which the blades are assumed to act as cantilever beams. The coupled modes and the twist effects are investigated.

RECIPROCATING (6)

Icing-Protection Requirements for Reciprocating-Engine Induction Systems. Willard D. Coles, Vern G. Rolling, and Donald R. Mulholland. *U.S., N.A.C.A., Report No. 982*, 1950. 24 pp., illus. 29 references. Superintendent of Documents, Washington. $0.20.

Investigations of all phases of ice-forming and ice-prevention problems in the induction system of a reciprocating engine have resulted in criteria for safe operation and new designs of induction systems.

First Use of Turbosuperchargers in Commercial Aviation. A. W. White, E. O. Henrickson, and F. W. Fernald. *S.A.E., National Aeronautic Meeting, New York, April 16–19, 1951, Preprint No. 604*. 10 pp., illus. $0.25. Operation of a turbosupercharger; advantages; installation; the Boeing Stratocruiser; the General Electric BH 4 turbosupercharger; new developments.

The Effect of Mixture Strength on Cylinder Head Temperature and Brake Horsepower. *United Aircraft Corp., Pratt & Whitney Aircraft Division, Manual of Engine Operation, Engine Operation Information Letter No. 17*, September 23, 1949 (Revised March 10, 1951). 3 pp., illus.

Specific Operating Instructions: Wasp Major TSB-G & B6. *United Aircraft Corp., Pratt & Whitney Aircraft Division, PWA. OI. 81 (Part No. 116942)*, February 1, 1947 (Revised March 1, 1951). 13 pp., illus., fold chart.

Torsional Vibration Investigations on the Musketeer Engine. E. Downham, Winifred Davidson, and M. O. Wolfe. *Gt. Brit., Aeronautical Research Council, Current Papers No. 34*, 1951 (June 1949). 14 pp., illus. 2 references. British Information Services, New York. $0.65. Experimental and theoretical analyses of the torsional vibration characteristics of the crankshaft of the Blackburn Musketeer 263-hp. 6-cylinder in-line engine.

ROCKET (4)

New Technique for Obtaining Heat-Transfer Parameters of the Wall and Combustion Gas in a Rocket Motor. M. E. Ellion. *American Society of Mechanical Engineers, Transactions*, Vol. 73, No. 2, February, 1951, pp. 109–114, illus. 7 references.

Laboratory test program developed at Bell Aircraft Corp. for the study of heat transfer through the rocket wall. To evaluate the suitability of various alloys for rocket-motor construction, a method was developed for obtaining gas side-wall temperatures in a rocket motor. The calculation procedure includes the effects of the variation of thermal properties with temperature. A table gives test results with eight alloys and copper. Test apparatus is illustrated.

The Use of Auxiliary Rockets in High-Speed Aircraft. Zb. Plaskowski. (*Flugwear und -Technik*, Vol. 12, No. 6, June, 1950, pp. 134–139.) *Aircraft Engineering*, Vol. 23, No. 265, March, 1951, pp. 72–75, illus. Analysis of the performance of the combination of a simple gas-turbine unit with auxiliary rockets; aircraft performance curves for rocket-assisted flight.

Discussion: Stability of Flow in a Rocket Motor, by D. F. Gunder and D. R. Friant. H. I. Ansoff and M. Yachter. *Journal of Applied Mechanics*, Vol. 18, No. 1, March, 1951, pp. 114–116. 2 references. Physical meaning and determination of "time lag."

Principles of Rocket-Turbopump Design. C. C. Ross. *American Rocket Society, Journal*, No. 84, March, 1951, pp. 21–33, illus. 5 references.

Basis of turbopump design so that the weight of the complete power plant will be at a minimum; effects of the principal variables of turbine and pump design; development of a method for studying optimum turbopump design for any rocket applications.

Tasks We Face. F. Zwicky. *American Rocket Society, Journal*, No. 84, March, 1951, pp. 3–20. 7 references.

Future developments in jet propulsion through a method of "morphological thinking," which is the systematic classification of scientific and technical devices. The morphological method is applied to the isothermal rocket engine and ram-jet, aeropulse, and hydroengines. The morphology of propellants is studied as the science of "metachemistry."

Production (36)

Saunders-Roe Princess. *Aircraft Production*, Vol. 13, No. 149, March, 1951, pp. 71–78, illus., cutaway drawings. 2 references.

Methods and equipment, including structure and assembly fixtures, for the construction of the after-hull and fin component and the mainplane components of the Saunders-Roe Princess flying boat.

Seat-Manufacture. I—Design-Considerations and Strength Requirements; Mechanical Testing. L. G. Burnard. *Aircraft Production*, Vol. 13, No. 150, April, 1951, pp. 99–104, illus.

Methods developed for the manufacture of both single and twin aircraft seats to fulfill safety, strength, and comfort requirements; procedures for mechanically testing the seat structure.

Metal-Bonding: A Review of Development Work on Metal Adhesive Processes by The Bristol Aeroplane Co., Ltd. F. H. Parker. (*Royal Aeronautical Society, Journal*, Vol. 55, No. 483, March, 1951, pp. 153–168.) *Aircraft Production*, Vol. 13, No. 150, April, 1951, pp. 107–114, illus.

Metal Adhesive Processes. F. H. Parker. *Royal Aeronautical Society, Journal*, Vol. 55, No. 483, March, 1951, pp. 153–168, illus. Redux process and manufacturing techniques using the process.

Investment Castings—Their Design and Limitations. D. F. B. Tedds. *The Engineer*, Vol. 191, No. 4962, March 2, 1951, pp. 292–294, illus. Advantages and commercial limitations of the investment-casting process from the designer's point of view.

The Fields of Utility of Investment Castings. R. L. Wood and D. Von Ludwig. *Mechanical Engineering*, Vol. 73, No. 3, March, 1951, pp. 191–197, illus.

Intelligent Testing and Inspection of Forgings Assures High Quality at Lower Cost. Lester F. Spencer. *Materials & Methods*, Vol. 33, No. 3, March, 1951, pp. 77–80, illus. 6 references.

Integrally Stiffened Wings in Super Connie. Fred S. Hunter. *American Aviation*, Vol. 14, No. 37, April 2, 1951, pp. 19, 20, 22, illus.

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Pre-Spun Shapes Simplify Drop Hammer Forming. Gilbert C. Close. *Aviation Age*, Vol. 15, No. 3, March, 1951, pp. 36, 37, illus.

Douglas Aircraft Co., Inc., uses prespun shapes to permit parts that require up to ten sets of staging dies to be finish-formed with a single set of dies. Tooling cost of the process is low.

Prop Extrusion Is Production Milestone. Irving Stone. *Aviation Week*, Vol. 54, No. 12, March 19, 1951, pp. 27, 28, 32, 35, illus.

Hot extrusion of one-piece, tapered, hollow steel propeller blades at Curtiss-Wright Corp. A 400-lb. billet of steel is extruded in a 5,500-ton horizontal Loewy press, giving a semifinished shank section that is reheated for the second extrusion; this step tapers the shank. In the third step, the unformed portion of the billet is extruded into a rough tube shape. About 0.015 in. of material is left on the tube for the finishing process; the tube is hydraulically pressed to give the final shape.

Gas-Turbine Steels; Machining Austenitic and Ferritic Alloys. I—Materials, Cutting-Tools, and Cutting-Fluids. II—Machining Conditions for Various Processes. K. J. B. Wolfe and P. Spear. *Aircraft Production*, Vol. 13, Nos. 149, 150, March, April, 1951, pp. 80–83; 117–120; illus. 33 references.

I. Fundamental problems of tool-material and design, cutting fluids, cutting-speed, feed, depth of cut in producing swarf from austenitic and ferritic alloys for maximum machining efficiency. Special machining and inspection techniques are not included. **II.** Conditions and procedures for handling the alloys during turning and boring, milling, broaching, tapping, drilling, reaming, grinding, filing, and linishing (the use of surface-coated abrasives); improvements in the machinability of the alloys.

Cast Milling-Cutters; New Development in Machining Practice by B.S.A. Tools Ltd. *Aircraft Production*, Vol. 13, No. 150, April, 1951, pp. 124, 125, illus.

Hot Dimpling Widens Metal Use. *Aviation Week*, Vol. 54, No. 14, April 2, 1951, pp. 21, 22, illus. Aircraft Tools hot-dimpling equipment, process, and applications.

Heat-Resistant Alloys: Applications of Welding Processes to Sheet Materials for Gas-Turbines. I, II. H. E. Lardge. *Aircraft Production*, Vol. 13, Nos. 149, 150, March, April, 1951, pp. 84–87; 121–123; illus. 19 references.

Fusion and resistance welding processes of heat-resistant alloys containing nickel and chromium; application of resistance-welding processes; stitch- and seam-welding; electrical hot-riveting process.

The Industrial Use of Blast Welding, Dealing in Particular with Ferrous Materials. *Institute of Welding, Transactions*, Vol. 14, No. 1 (*Welding Research*, Vol. 5, No. 1), February, 1951, pp. 135r–153r, illus. 3 references.

Cost Control Engineering. II—Cost and Design Data. John Van Hamersveld. *Machine Design*, Vol. 23, No. 3, March, 1951, pp. 132–138, illus. Pocket manual developed; cost and time data linked.

Design for Economy. W. T. Minech. *Machine Design*, Vol. 23, No. 3, March, 1951, pp. 139–141, illus.

Cost analysis in the design stage to provide for economy in material, tooling, and labor and to determine the optimum process and material for satisfactory quantity production at minimum cost.

Optical Inspection; Profile-Projector for Small Machined Parts. *Aircraft Production*, Vol. 13, No. 149, March, 1951, pp. 95, 96, illus. Design and operation of a profile-projector built by Newton and Co., Ltd.

Determining Practical Tolerances. Wayne A. Ring. *Machine Design*, Vol. 23, No. 3, March, 1951, pp. 121–124, illus. 2 references.

Statistical control of component production allows for final dimensional tolerances for lowest manufacturing costs. Charts are given for determining the probability of interference of two overlapping normal distributions and of two overlapping rectangular distributions.

Streamlining Acceptance Inspection; New Military Sampling Tables Standardize Evaluation Procedure. William R. Pabst, Jr. *Ordnance*, Vol. 35, No. 185, March-April, 1951, pp. 485–488, illus.

The Toolroom; Its Relation to Production. H. W. Townsend. *Aircraft Production*, Vol. 13, No. 149, March, 1951, pp. 92–94, illus. Function of a toolroom; the tool-maker; tooling economics; planning and control; maintenance.

Propellers (11)

Vibratory Stresses in Propellers Operating in the Flow Field of a Wing-Nacelle-Fuselage Combination. Vernon L. Rogallo, John C. Roberts, and Merritt R. Oldaker. *U.S., N.A.C.A., Technical Note No. 2308*, March, 1951. 33 pp., illus. 5 references.

Determination of first-order vibratory stresses and evaluation of the process of predicting these stresses. Stress measurements were carried out on 3- and 4-bladed hollow steel propellers (13 ft. in diameter) to obtain the propeller response to oscillating air loads.

Note on Wing-Nacelle-Airscrew Interference. E. Ower, R. Warden and R. C. Pankhurst. *Gt. Brit., Aeronautical Research Council Reports and Memoranda No. 2439*, 1950 (June, 1940). 6 pp., illus. 5 references. British Information Services, New York. $0.35.

Measurement of Thrust and Torque Grading on High-Pitch Model Airscrews. C. N. H. Lock, H. Bateman, and H. L. Nixon. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2477*, 1950 (August 3, 1939). 29 pp., illus. 10 references. Measurements of four propellers at low tip speeds using yaw and pressure tubes are tabulated and analyzed.

Prop Extrusion Is Production Milestone. Irving Stone. *Aviation Week*, Vol. 54, No. 12, March 19, 1951, pp. 27, 28, 32, 35, illus. Hot extrusion of one-piece, tapered, hollow steel propeller blades at Curtiss-Wright Corp.

The Determination of the Fixed Root Frequencies of Propeller Blades Using Scale Models and the Results Compared with Calculations. G. A. Luck and W. Lowes. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2391*, 1950 (November, 1945). 10 pp., illus. 2 references. British Information Services, New York. $0.65.

Investigation of fixed-root natural frequencies and vibration modes using models of de Havilland propellers designed for the Sabre and contrarotating propeller Sabre engines. Photographs show the nodal patterns obtained.

Reference Literature (47)

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YEARBOOKS

12th Annual Directory. *Aero Digest*, Vol. 62, No. 3, March, 1951. 164 pp., illus.

Specifications, performance, and photographs of U. S. military, transport, and personal aircraft; helicopters; reciprocating and jet power plants; propellers; alphabetical lists of company addresses and key personnel of air-frame, power-plant, and accessories manufacturers; directory of manufacturers of airborne accessories classified alphabetically under product listings.

33rd Annual Statistical Issue. *Automotive Industries*, Vol. 104, No. 6, March 15, 1951. 436 pp., illus. Includes aviation data: aircraft and engine production, shipments, civil aircraft registrations and shipments; airport registrations.

Rotating Wing Aircraft (34)

A New Ram-Jet Helicopter. C. Colin Cooper. *The Aeroplane*, Vol. 80, No. 2066, February 23, 1951, pp. 236–238, illus. Design details of the Hiller "Hornet," a twin ram-jet powered helicopter for private use.

Notes on the Development of the Bristol 171 Helicopter; An Outline of the Distinctive Features of the Type That Were Evolved As a Result of Experience. F. W. Stokes. *Aircraft Engineering*, Vol. 23, No. 265, March, 1951, pp. 67–71, illus., cutaway drawings.

Bristol 173 (Twin-Engined Helicopter). C. B. Bailey-Watson. *Flight*, Vol. 59, No. 2199, March 16, 1951, pp. 311–319, illus., cutaway drawings.

Britain's First Twin-Engined Helicopter (Bristol Type 173). *The Aeroplane*, Vol. 80, No. 2069, pp. 321–328, illus., cutaway drawings.

The Helicopter Prospect. *Flight*, Vol. 59, No. 2200, March 23, 1951, pp. 337–339, illus. Abstract of a report by a committee of the British Ministry of Civil Aviation.

Helicopters Applied to Local Air Service Operation: British Experience and Requirements. N. E. Rows. *S.A.E., National Aeronautic Meeting, New York, April 16–19, 1951, Preprint No. 615.* 49 pp., illus. $0.25. Commercial operations by British European Airways Corp.

Helicopters Applied to Local Air Service Operation: American Plan. C. M. Belinn. *S.A.E., National Aeronautic Meeting, New York, April 16–19, 1951, Preprint No. 614.* 16 pp., illus. $0.25. Commercial operations by Los Angeles Airways, Inc.

Helicopter Maintenance, II. Accessibility Servicing and Testing of Components. G. E. Walker. **An Analysis of Present-Day Helicopter Maintenance.** F. L. Swain. **Materials and the Fatigue Aspect.** W. E. Cooper. *The Technical Instructor*, Vol. 6, No. 2, February, 1951, pp. 9–18.

Full-Scale-Tunnel Investigation of the Static-Thrust Performance of a Coaxial Helicopter Rotor. Robert D. Harrington. *U.S., N.A.C.A., Technical Note No. 2318*, March, 1951. 23 pp., illus. 2 references.

Investigation of the static-thrust performance, tip speed range up to 500 ft. per sec., of a coaxial helicopter rotor that is tapered in plan form and thickness ratio. Measurements for the coaxial and single rotor are compared with hovering-performance theory.

Charts for Estimation of Longitudinal-Stability Derivatives for a Helicopter Rotor in Forward Flight. Kenneth B. Amer and F. B. Gustafson. *U.S., N.A.C.A., Technical Note No. 2309*, March, 1951. 51 pp., illus. 11 references.

Sciences, General (33)

MATHEMATICS

A Digital Electronic Correlator. Henry E. Singleton. *Massachusetts Institute of Technology, Research Laboratory of Electronics, Technical Report No. 152*, February 21, 1950. 30 pp., illus. 10 references.

The theory of random processes is used in the design of a digital electronic correlator for communications problems. A set of probability distribution functions represents the sets of possible signals for which the communication equipment operates. Binary digital techniques are used for multiplication, integration, and storage.

Calculating Machines—New Tools for the Designer. E. Bromberg and R. D. McCoy. *Product Engineering*, Vol. 22, No. 3, March, 1951, pp. 85–88, illus. 7 references. Digital and analog computers (differential computers); speed of operation; applications.

A Study of the Numerical Solution of Partial Differential Equations. George G. O'Brien, Morton A. Hyman, and Sidney Kaplan. *Journal of Mathematics and Physics*, Vol. 29, No. 4, January, 1951, pp. 223–251, illus. 9 references.

Analysis of the accuracy of a finite difference solution to a partial differential equation in terms of the convergence and stability of the difference scheme. A method is given for determining the stability of partial difference equations, and implicitly difference schemes are studied. The magnitudes of the truncation error and the numerical error (for various methods of numerical solution) are investigated for a simple parabolic problem, emphasizing the question of whether the lack of convergence or lack of stability is chiefly responsible for the error. The analysis applies to partial differential equations of the parabolic and hyperbolic types, but some results apply also to elliptic problems.

A Survey of the Theory of Boundedness, Stability, and Asymptotic Behavior of Solutions of Linear and Non-Linear Differential and Difference Equations. Richard Bellman. *U.S., Office of Naval Research, Washington, Report No. NAVEXOS P-596*, January, 1949. 156 pp., illus. 16 references.

Forced Periodic Solutions of a Stable Non-Linear System of Differential Equations. A. B. Farnell, C. E. Langenhop, and N. Levinson. *Journal of Mathematics and Physics*, Vol. 29, No. 4, January, 1951, pp. 300–302.

A Generalization of Reversion Formulae with Their Applications to Non-Linear Differential Equations. A. C. Sim. *Philosophical Magazine*, Vol. 42 (7th Series), No. 326, March, 1951, pp. 228–238, illus. 7 references.

An Iterative Numerical Method for Nonlinear Vibrations. J. E. Brock. *Journal of Applied Mechanics*, Vol. 18, No. 1, March, 1951, pp. 1–11, illus. 11 references.

An algebraic iterative procedure combined with numerical integration provides a rapid, accurate, and almost automatic method of obtaining nonlinear vibration characteristics. The time t is used as the independent variable. Proof of convergence is not included.

The Least Squares Solution for a Set of Complex Linear Equations. R. Turetsky. *Quarterly of Applied Mathematics*, Vol. 9, No. 1, April, 1951, pp. 108–110. 1 reference.

The Principle of Minimized Iterations in the Solution of the Matrix Eigenvalue Problem. W. E. Arnoldi. *Quarterly of Applied Mathematics*, Vol. 9, No. 1, April, 1951, pp. 17–29. 3 references.

A Convenient General Solution of the Confluent Hypergeometric Equation, Analytic and Numerical Development. T. S. Kuhn. *Quarterly of Applied Mathematics*, Vol. 9, No. 1, April, 1951, pp. 1–16. 5 references.

Standards on Electronic Computers: Definitions of Terms, 1950 (Standard No. 50 IRE 8.S1.). *Institute of Radio Engineers, Proceedings*, Vol. 39, No. 3, March, 1951, pp. 271–277.

A Simple Geometric Proof of Buckingham's π-Theorem. Stanley Corrsin. *American Journal of Physics*, Vol. 19, No. 3, March, 1951, pp. 180, 181, illus. 3 references.

Coulomb Wave Functions Expressed in Terms of Bessel-Clifford and Bessel Functions. Milton Abramowitz. *Journal of Mathematics and Physics*, Vol. 29, No. 4, January, 1951, pp. 303–308. 4 references.

Tables of Roots and Incomplete Integrals of Associated Legendre Functions of Fractional Orders. Pierre A. Carrus and Charlotte G. Treuenfels. *Journal of Mathematics and Physics*, Vol. 29, No. 4, January, 1951, pp. 282–299. 5 references.

On the Absolute Riesz Summability of Fourier Series and Allied Series. R. Mohanty. *London Mathematical Society, Proceedings*, Vol. 52 (Series 2), Part 4, March 18, 1948, pp. 295–320, illus. 12 references.

PHYSICS

The Scattering of Atoms from Diatomic Molecules. Charles F. Curtiss. *Wisconsin, University, Naval Research Laboratory, Department of Chemistry, Report No. CM-633*, February 26, 1951. 22 pp., illus. 5 references.

Quantum mechanics of the collision of an atom with a diatomic molecule. This low-energy collision is an example of the scattering of particles by a nonspherical potential field.

Space Travel

Problems of Missiles Entering the Atmosphere. T. Nonweiler *British Interplanetary Society, Journal*, Vol. 10, No. 1, January, 1951, pp. 26–35, illus. 2 references. Retardation process; effects of gravitation and friction forces; velocity of impact.

Entry into Circular Orbits. I. Derek F. Lawden. *British Interplanetary Society, Journal*, Vol. 10, No. 1, January, 1951, pp. 5–17, illus. 4 references.

The problem of a suitable trajectory for the transfer of a body from the earth's surface into a circular orbit about the earth; mathematical analysis of the portion of the trajectory which is a small arc immersed in the atmosphere, considering the effects of air resistance and assuming the gravity to be constant.

The Station in Space. Hermann Oberth. (*Wege zur Raumschiffahrt*, Munich, 1929, Part 4, Chapter 20, pp. 350–353.) *Rocketscience*, Vol. 5, No. 1, March, 1951, pp. 2–5, illus.

Structures (7)

A Suggested Method of Increasing the Damping of Aircraft Structures. D. H. D. Cooper. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2398*, 1950 (August, 1946). 13 pp., illus. 4 references. British Information Services, New York. $0.65.

Investigation of the problem of increasing the damping of laminated beams by use of inserts of a material that has high

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State and Development of Flutter Calculation. A. Teichmann. (*Lilienthal-Gesellschaft für Luftfahrtforschung, Bericht Nr. 135*, 1941, pp. 11–20.) *U.S., N.A.C.A., Technical Memorandum No. 1297*, March, 1951. 26 pp., illus. Fundamentals of approach to the problem; nature of the flutter calculation; rationalization of the calculation.

An Iterative Numerical Method for Nonlinear Vibrations. J. E. Brock. *Journal of Applied Mechanics*, Vol. 18, No. 1, March, 1951, pp. 1–11, illus. 11 references.

A rapid and accurate method of determining the characteristics of oscillations of an undamped system having a single degree of freedom and symmetric, nonlinear elasticity. An algebraic iterative procedure is combined with numerical integration; each stage involves two integrations.

Discussion: A Method for Determining Mode Shapes and Frequencies Above the Fundamental by Matrix Iteration, by H. I. Flomenhoft. J. B. Duke, A. C. Gilbert, and K. B. Gillmore. **Authors' Closure.** *Journal of Applied Mechanics*, Vol. 18, No. 1, March, 1951, pp. 111–114. 4 references. Restrictions imposed on the method of sweeping in matrix iteration procedure.

Flutter of a Uniform Wing with an Arbitrarily Placed Mass According to a Differential-Equation Analysis and a Comparison with Experiment. Harry L. Runyan and Charles E. Watkins. *U.S., N.A.C.A., Report No. 966*, 1950. 17 pp., illus. 13 references. Superintendent of Documents, Washington. $0.20.

A differential equation method is set up for flutter analysis of any uniform cantilever wing with an arbitrarily placed concentrated weight, and the solution is developed, based on an extension of the method of Goland and Luke. Specific normal modes of vibration need not be assumed. The method is applied to a particular wing-weight problem; results agree well with experiments. The method of Goland and Luke is derived for a wing carrying a tip weight. Operational methods of solving boundary-value problems are explained. The solution obtained for the flutter determinant is used with the solution of the differential equations to obtain the amplitudes and phase angles of the deflection curves.

Coupled Free Vibrations of a Swept Wing. A. E. Engelbrecht *Journal of the Aeronautical Sciences*, Vol. 18, No. 5, May, 1951, pp. 329–338, illus. 14 references.

Approximate determination of the natural frequencies of the coupled bending and torsional free vibrations of a swept wing by replacing the continuous elastic wing by a composite wing that consists of a finite number of masses connected by weightless supporting structures.

Electrical Analogy Determination of Torsional Vibration Frequencies of Shaft Systems. M. Ballet. (*Revue Générale de Mécanique*, Vol. 34, No. 24, December, 1950, pp. 429–434.) *Engineers' Digest*, Vol. 12, No. 3, March, 1951, pp. 96–98, illus. 5 references.

Evaluation of the electrical analogy method and of four analogies used for torsionally vibrating systems; test methods and equipment that represent the mechanical system; applications.

Photoelastic Stress Analysis Useful in Design of Metal Parts. I—Two-Dimensional Method. M. M. Leven. *Materials & Methods*, Vol. 33, No. 3, March, 1951, pp. 70–73, illus. Evaluation of the method and apparatus; optical principles involved; materials suitable for photoelastic stress analysis; applications.

Measurement of Pressure by Means of Metallic Test-Pieces. E. Fischer. (*Verein deutscher Ingenieure, Zeitschrift*, Vol. 93, No. 2, January 11, 1951, pp. 37–40.) *Engineers' Digest*, Vol. 12, No. 3, March, 1951, pp. 94–96, illus. 1 reference.

Loads can be measured by means of metallic test-pieces, preferably made of electrolytic copper. The test-piece is subjected to the load to be measured, the magnitude of which is later indicated by a break in the stress-strain curve. The procedure is suitable for both static and impact tests.

Discussion: A Mechanical Analyzer for Computing Transient Stresses in Airplane Structures, by R. L. Bisplinghoff, T. H. H. Pian, and L. I. Levy. Walter Ramberg and R. H. Scanlan. **Authors' Closure.** *Journal of Applied Mechanics*, Vol. 18, No. 1, March, 1951, pp. 109, 110. 3 references.

Shakedown in Continuous Media. P. S. Symonds. *Journal of Applied Mechanics*, Vol. 18, No. 1, March, 1951, pp. 85–89, illus. 7 references.

A proof is developed for the shakedown theorem for elastic-plastic bodies; the theorem is applied to the problem of a bar under independently variable axial force and twisting moment.

Stress Concentrations Around Spheroidal Inclusions and Cavities. R. H. Edwards. *Journal of Applied Mechanics*, Vol. 18, No. 1, March, 1951, pp. 19–30, illus. 7 references.

Determination of an exact solution for the distribution of stress around a prolate spheroidal core in an elastic body of homogeneous isotropic material when the body is in an arbitrary uniform state of stress infinitely far from the inclusion and when the system is at uniform temperature. Two elastic solutions (one defines the stress and displacement fields over the inclusion; the other defines these fields over the surrounding body) are obtained for five loading conditions at infinity. An exact solution is obtained for the thermal stress distribution arising from distinct uniform temperature changes in the body and inclusion.

Discussion: Elastic-Plastic Analysis of Structures Subjected to Loads Varying Arbitrarily Between Prescribed Limits, by P. S. Symonds and W. Prager. George Winter and T. M. Charlton. **Authors' Closure.** *Journal of Applied Mechanics*, Vol. 18, No. 1, March, 1951, pp. 117–119. 8 references.

Structural Analysis by Distribution of Deformation. C. V. Klouček. *Quarterly of Applied Mathematics*, Vol. 9, No. 1, April, 1951, pp. 77–88, illus. 7 references. Theoretical analysis of the basic relations of the method.

Machine Design Data Sheet: Design Factors for Stress Concentration. II—Notches and Grooves in Tension and Torsion. R. E. Peterson. *Machine Design*, Vol. 23, No. 3, March, 1951, pp. 161–165, illus. 4 references.

Charts for obtaining the stress-concentration factor for a notched flat bar in tension, for a grooved shaft in tension, for a grooved shaft in torsion, and for the combined stress-concentration and shear-energy factor for a grooved shaft in tension. The curves represent values calculated by the Neuber theory.

Evaluation of Stress Distribution in the Symmetrical Neck of Flat Tensile Bars. Julius Aronofsky. *Journal of Applied Mechanics*, Vol. 18, No. 1, March, 1951, pp. 75–84, illus. 16 references.

The local strains and strain distribution in the necks of two flat tensile specimens have been measured. A strain-hardening function for the material was obtained from the results of tension tests on round bars. This strain-hardening function and the measured strains are used to determine the stress distribution in the neck. Good agreement between the calculated and measured fracture load was obtained.

Design Data: Factors of Stress Concentration for Slotted Bars in Tension and Bending. M. M. Frocht and M. M. Leven. *Journal of Applied Mechanics*, Vol. 18, No. 1, March, 1951, pp. 107, 108, illus. Curves give the factor of stress concentration k for slotted bars in tension and slotted bars in bending.

Discussion: Critical Load of Columns of Varying Cross Section, by W. T. Thomson. E. D'Appolonia. *Journal of Applied Mechanics*, Vol. 18, No. 1, March, 1951, pp. 119, 120, illus. 1 reference. Numerical procedure and tabular scheme for determining the critical load.

The Dynamics of the Buckling of Elastic Columns. N. J. Hoff. *Journal of Applied Mechanics*, Vol. 18, No. 1, March, 1951, pp. 68–74. 7 references.

The behavior of an elastic column of uniform cross section, compressed in a commercial testing machine, is calculated with the aid of the dynamic equations of motion. The buckling test is examined analytically to discover a better correlation between theory and experiment.

Analytical and Experimental Investigation of Effect of Twist on Vibrations of Cantilever Beams. Alexander Mendelson and Selwyn Gendler. *U.S., N.A.C.A., Technical Note No. 2300*, March, 1951. 48 pp., illus. 12 references.

Presentation of a method, based on the use of Station Functions, for determining the coupled modes and frequencies of non-uniform twisted cantilever beams and to determine the effect of twist on the vibrational frequencies of such beams. An approximate solution is given for the general case of coupled bending–bending-torsion vibrations; the general equations reduce to the special bases of bending-bending, bending-torsion, bending, and torsion vibrations. Matrix notation is used throughout.

Spar Depth and Weight. W. Tye and R. G. Thorne. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2569*, 1950 (December, 1941). 3 pp., illus. British Information Services, New York. $0.25.

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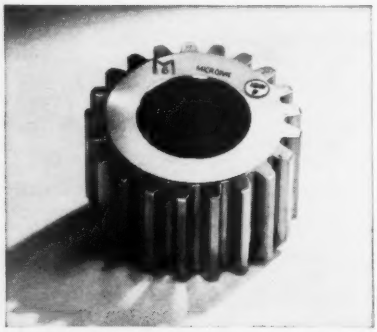

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Effect of Creep on Column Deflection. T. P. Higgins, Jr. *The RAND Corporation, Report No. P-51,* December 1, 1948. 25 pp., illus. 9 references.

A Note on the Buckling of Struts. Harold Lurie. *Royal Aeronautical Society, Journal,* Vol. 55, No. 483, March, 1951, pp. 181–184, illus.

The complete solution, including all possible modes, of a column with four boundary conditions, by use of the fourth-order loading equations. With this equation, a general equation that is independent of the boundary conditions can be set up. This is then solved as an eigenvalue problem for nonzero solutions. The process is applied to a column fixed at both ends. It is shown that this solution gives more complete results than the classical solution based on energy considerations.

Readers' Forum: Formulas for Bending with Axial Tension. Alfred S. Niles. *Journal of the Aeronautical Sciences,* Vol. 18, No. 5, May, 1951, pp. 356, 357. 1 reference.

Formulas for a beam-column in axial tension; demonstration of a rule by which the signs in a formula for axial tension can be determined from those in the conjugate formula for axial compression.

Design and Calculation of Spot-Welded Joints Under Static Shear Loads. H. Zschokke and R. Montandon. (*Schweizer Archiv,* Vol. 16, No. 9, September, 1950, pp. 257–271.) *Engineers' Digest,* Vol. 12, No. 3, March, 1951, pp. 85–89, illus. 4 references.

Design formulas are derived for calculating the strength of a spot-welded joint and for the dimensioning of a joint for a given static shear load. The weld diameter is first specified, and the strip width or pitch is set so that single spot welds fail just at the weld, multiple spot welds in the sheet. The most economic designs are calculated for single- and double-lap joints and for single and multiple spot-welded joints; tests verify the design.

Critical Stress of Ring-Stiffened Cylinders in Torsion. Manuel Stein, J. Lyell Sanders, Jr., and Harold Crate. *U.S., N.A.C.A., Report No. 989,* 1950. 7 pp., illus. 7 references. Superintendent of Documents, Washington. $0.15.

Calculation of a chart of the theoretical critical stress of a ring of stiffened cylinders in shear arising from torsion in nondimensional parameters is obtained by solving the equation of equilibrium by the Galerkin method. This solution is carried out, and equations give the sixth-order determinants for the cases of $n = 1, 2, 3,$ and ∞ where $n = 1$ is one ring stiffener, $n = 2$ is two stiffeners, etc.

The Solution of Elastic Plate Problems by Electrical Analogies. R. H. MacNeal. *Journal of Applied Mechanics,* Vol. 18, No. 1, March, 1951, pp. 59–67, illus. 8 references.

An electric analogy method for the solution of elastic plates in which the problem is formulated in finite-difference terms. The difference equations are solved by an electric analog computer. Slopes, moments, and shears can be measured directly. The analogies are based on the equations for a thin plate, assuming small deflections.

Influence of Rotatory Inertia and Shear on Flexural Motions of Isotropic, Elastic Plates. R. D. Mindlin. *Journal of Applied Mechanics,* Vol. 18, No. 1, March, 1951, pp. 31–38, illus. 14 references.

A two-dimensional theory of flexural motions of plates, analogous to Timoshenko's one-dimensional theory of bars, is derived from the three-dimensional equations of elasticity. Theorems are derived for kinetic and potential energies, uniqueness, and initial and boundary conditions. Three boundary conditions must be satisfied.

The Effect of Flange Stiffness on the Stresses in a Plate Web Spar Under Shear. D. M. A. Leggett and H. G. Hopkins. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2434,* 1950 (November, 1941). 12 pp., illus. 1 reference. British Information Services, New York. $0.65. Theoretical check for Kuhn's test results for the limiting case in which the web is buckled and is acting as a Wagner tension field.

Linearized Solution and General Plastic Behavior of Thin Plate with Circular Hole in Strain-Hardening Range. M. H. Lee Wu. *U.S., N.A.C.A., Technical Note No. 2301,* March, 1951. 41 pp., illus. 19 references.

Linearized solution based on the deformation theory of plasticity for finite strains. Tables are given for obtaining the maximum strain and stress and strain distributions for the problem of a given material.

Thermodynamics (18)

Further Experiments on the Flow and Heat Transfer in a Heated Turbulent Air Jet. Stanley Corrsin and Mahinder S. Uberoi. *U.S., N.A.C.A., Report No. 998,* 1950. 17 pp., illus. 24 references. Superintendent of Documents, Washington. $0.20. Experimental study of heat transfer in turbulent shear flow using a hot-wire method for simultaneously measuring the velocity and temperature fluctuations.

A Contribution to the Exact Solutions of the Problem of a One-Dimensional Shockwave in a Viscous, Heat Conducting Fluid. H. J. Reissner and L. Meyerhoff. *Polytechnic Institute of Brooklyn, Report No. 138,* November, 1948. 31 pp., illus. 9 references.

I—Maxwell's Demon Cannot Operate: Information and Energy. II—Physical Entropy and Information. L. Brillouin. *Journal of Applied Physics,* Vol. 22, No. 3, March, 1951, pp. 334–337; 338–343, illus. 11 references.

I. An explanation of the operation of Maxwell's demon in an enclosure at constant temperature. Introduction of a light source leads to an explanation in entropy terms, considering the information as part of a "negative entropy" cycle. **II.** Definition of entropy by the laws of statistical thermodynamics; evaluation of C. E. Shannon's formulas for "entropy of information."

Investigation of Turbulent Flow and Heat Transfer in Smooth Tubes, Including the Effects of Variable Fluid Properties. R. G. Deissler. *American Society of Mechanical Engineers, Transactions,* Vol. 73, No. 2, February, 1951, pp. 101–107, illus. 11 references.

Derivation of an equation for the velocity distribution close to a smooth wall which represents both the laminar and buffer layers. This equation and von Kármán's solution for flow at a distance from the wall were extended to include flow with heat transfer for a fluid with a Prandtl Number of 1 where there is an appreciable variation of fluid properties due to temperature variation across the tube.

New Technique for Obtaining Heat-Transfer Parameters of the Wall and Combustion Gas in a Rocket Motor. M. E. Ellion. *American Society of Mechanical Engineers, Transactions,* Vol. 73, No. 2, February, 1951, pp. 109–114, illus. 7 references.

Laboratory program developed at Bell Aircraft Corp. for the study of heat transfer through the rocket wall. A thick-walled water-cooled nozzle is used as a heat meter, and the calculation procedure includes the effects of the variation of thermal properties with temperature.

Readers' Forum: Heat Transfer by Laminar Flow from a Rotating Plate. Knox Millsaps and Karl Pohlhausen. *Journal of the Aeronautical Sciences,* Vol. 18, No. 5, May, 1951, pp. 354, 355. 4 references.

Readers' Forum: Convective Heat Transfer from Spheres in a Free-Molecule Flow. F. M. Sauer. *Journal of the Aeronautical Sciences,* Vol. 18, No. 5, May, 1951, pp. 353, 354, illus. 1 reference.

Emissivity Calculations for Diatomic Gases. S. S. Penner. *Journal of Applied Mechanics,* Vol. 18, No. 1, March, 1951, pp. 53–58, illus. 7 references.

Development of an approximate method for estimating radiant-heat transfer from gaseous emitters; explanation of the relation between this simplified theoretical approach and experimental spectroscopic and heat-transfer studies. The absorption spectra of diatomic molecules are examined; effective band widths and average absorption coefficients are calculated.

Water-Borne Aircraft (21)

Application of Basic Research to Seaplane Design. John D. Pierson. *S.A.E., National Aeronautic Meeting, New York, April 16–19, 1951, Preprint No. 606.* 9 pp., illus. 4 references. $0.25.

Use of classical hydrodynamic theory and empirical analysis of model test data and full-scale experience, model tests, and specific studies of planing action to evolve a satisfactory seaplane design; application to specific designs.

The Seaplane in the U.S. Coast Guard. D. B. MacDiarmid. *S.A.E., National Aeronautic Meeting, New York, April 16–19, Preprint No. 607.* 7 pp., illus. $0.25.

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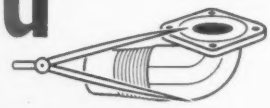

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Saunders-Roe Princess. *Aircraft Production*, Vol. 13, No. 149, March, 1951, pp. 71–78, illus., cutaway drawings. 2 references.

Methods and equipment, including structure and assembly fixtures, for the construction of the after-hull and fin component and the mainplane components of the Saunders-Roe Princess flying boat.

Wind Tunnels & Research Facilities

Wall Interference in Wind Tunnels of Closed Rectangular Section. J. Sanders and J. R. Pounder. *Canada, National Research Council, Aeronautical Report No. AR-7 (N.R.C. 2039, MA-180)*, 1949. 62 pp., illus. 39 references.

Theory of the effects of the walls of a wind tunnel on a three-dimensional airfoil, consideration being restricted to perfect fluid theory. Formulas that hold for any shape of wind tunnel are obtained, and the parameters that occur in these formulas are evaluated for closed rectangular tunnels.

Blockage Corrections for Three-Dimensional-Flow Closed-Throat Wind Tunnels, with Consideration of the Effect of Compressibility. John G. Herriot. *U.S., N.A.C.A., Report No. 995*, 1950. 13 pp., illus. 14 references. Superintendent of Documents, Washington. $0.10.

Formulas are given for obtaining the corrections for solid and wake blockage and for the pressure gradient due to the wake for three-dimensional models that are small relative to wind-tunnel dimensions. The corrections are applied to a body of revolution and a three-dimensional unswept wing.

Correction Factors for Wind Tunnels of Elliptic Section with Partly Open and Partly Closed Test Section. F. Riegels. (*Luftfahrtforschung*, Vol. 16, No. 1, January, 1939, pp. 26–30.) *U.S., N.A.C.A., Technical Memorandum No. 1310*, March, 1951. 18 pp., illus. 9 references.

Condensation of Water Vapor in the Shock Tube Below 150°K. P. Wegener and G. Lundquist. *Journal of Applied Physics*, Vol. 22, No. 2, February, 1951, p. 233, illus. 5 references.

A Method for Designing Wind Tunnel Contractions. R. Harrop. *Royal Aeronautical Society, Journal*, Vol. 55, No. 483, March, 1951, pp. 169–180, illus. 6 references.

Development of a design procedure for a circular-cross-section contraction having a favorable pressure gradient, using incompressible flow theory. The theory is compared with results from a model of a supersonic wind tunnel of rectangular-cross-section contraction.

Contracting Ducts of Finite Length. L. G. Whitehead, L. Y. Wu, and M. H. L. Waters. *The Aeronautical Quarterly*, Vol. 2, Part 4, February, 1951, pp. 254–271, illus. 10 references.

A method is developed for two-dimensional design of wind-tunnel contractions which gives a rapid change of cross section with small adverse pressure gradients. A boundary is chosen in the hodograph plane, and the flow is found by the method of images, assuming frictionless flow. The process is applied to the design of a tunnel with a contraction ratio of 7.25. The method is extended to the three-dimensional case in which the velocity potential and stream function of the two-dimensional case appear as independent variables.

The Design of Two-Dimensional Contraction Sections. Paul A. Libby and Howard R. Reiss. *Quarterly of Applied Mathematics*, Vol. 9, No. 1, April, 1951, pp. 95–98, illus 4 references.

Design of a contraction section that is essentially two-dimensional and in which the inlet flow is approximately uniform and axial by use of the hodograph method for incompressible, two-dimensional potential flow.

The Aerodynamic Wind Tunnel at Modane-Avrieux. C. Carty. *The Engineer*, Vol. 191, No. 4962, March 2, 1951, pp. 280–282, illus. Single-return wind tunnel for large-scale testing of aircraft engines and models. The tunnel operates on hydroelectric power.

Density Measurements in Supersonic Flow by Means of the X-Ray Absorption Method. Eva M. Winkler. *Journal of Applied Physics*, Vol. 22, No. 2, February, 1951, pp. 201, 202, illus. Procedure and apparatus, suitability, and limitations of measurements. Sample data for undisturbed flow at $M = 2.83$ are presented.

The Properties of Crossed Flexure Pivots, and the Influence of the Point at Which the Strips Cross. W. H. Wittrick. *The Aeronautical Quarterly*, Vol. 2, Part 4, February, 1951, pp. 272–292, illus. 2 references.

Study of the variation of rotational stiffness in crossed flexure pivots that are used for the fulcrums of the arm in wind-tunnel balances; relation between torque and rotation; analysis of maximum stresses.

Optimum Source Size for the Mach-Zehnder Interferometer. F. D. Bennett. *Journal of Applied Physics*, Vol. 22, No. 2, February, 1951, pp. 184–190, illus. 2 references.

A vector-analytic treatment of the ideal Mach-Zehnder interferometer. General results are obtained in a concise easily solvable form for the optimum source size and shape for a large class of interferometers.

Hypersonic Flow at a Mach Number of 10. I. D. V. Faro, T. R. Small, and F. K. Hill. *Journal of Applied Physics*, Vol. 22, No. 2, February, 1951, pp. 220–222, illus. 4 references.

Wind-tunnel apparatus for hypersonic flow studies. The nozzle used consists of a 10° truncated cone with a small circular throat from which the gas expands and flows into a cylindrical section. A schematic drawing shows the working section of the tunnel.

A Superposition Analysis of the Turbulent Boundary Layer in an Adverse Pressure Gradient. Donald Ross and J. M. Robertson. *Journal of Applied Mechanics*, Vol. 18, No. 1, March, 1951, pp. 95–100, illus. 12 references. Superposition method of analysis was developed in the study of diffuser flow in the design of a large water tunnel at The Pennsylvania State College.

Supersonic Flow Investigations with a "Hydraulic Analogy" Water Channel. Joseph Black and O. P. Mediratta. *The Aeronautical Quarterly*, Vol. 2, Part 4, February, 1951, pp. 227–253, illus. 19 references.

Construction of a water channel at the University of Bristol for the investigation of the analogy between the two-dimensional flow of a gas and that of shallow water with a free surface. Both continuous and discontinuous flow were examined with a view to determining the limitations of the analogy.

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Aeronautical Reviews — BOOKS

Methods of Operations Research

By Philip M. Morse and George E. Kimball. New York, The Technology Press of Massachusetts Institute of Technology and John Wiley & Sons, Inc., 1950. 158 pp., figs. $4.00.

This book is unqualifiedly recommended for study by all forward-looking executives. Whether the executive be in industry, in public service, or on military duty, a careful perusal of the book should convince him that most of the guesswork can be eliminated from the conduct of his operations by substituting these relatively new scientific analysis methods for the intuitive or shotgun approach so often relied upon. Operations research provides practical answers but, of course, will not furnish a panacea for all of the executive's problems, because no scientific methodology involving probability and change can be exact. However, if one has to take chances, it is reassuring to be able to calculate the odds and to have them predominantly on one's own side.

Operations research was developed during World War II and was proved to be of the utmost value, as illustrated by the many carefully documented examples throughout the text. Lack of such scientific analysis would certainly have prolonged the war. Its importance to the final successful outcome cannot be overemphasized.

It is pertinent and timely, in light of present world conditions, that this declassified edition of the authors' earlier work be published now. The principles and procedures involved in this special type of scientific analysis have extraordinarily broad application to nonmilitary operations, and the release of such a valuable basic reference book has long been anticipated.

Although the interest of the executive in operations research is stressed in the above remarks, scientists, mathematicians, engineers, and students will find it equally absorbing and thought provoking. There is a fascinating challenge to the scientific mind in producing logical and practical answers to difficult operational problems when only limited or apparently unrelated data are available for analysis. The analytical reasoning involved no doubt explains why so many biologists and physicists become operations research analysts.

The authors point out that the analyst's job in nonmilitary operations is often simplified because of the relatively large amount of available statistical data. There are often so many data in peacetime that the main problem is the proper selection of the most sensitive parameters. These are the ones whose variations have the most influence on operations. In wartime the effects of operations are often behind the enemy lines and unobtainable by the analyst in significant statistical quantity. In this event, all available parameters must be considered, and their influence must be properly assessed. The authors succinctly state: "The final aim of operations research, of course, is to predict future operations and to understand them well enough so as to be able to modify them to produce new or better results. The aim is not simply to record past operations or just to explain them; in this respect the work differs from the usual statistical analysis."

The first chapter of the book presents background and introduction, while the last chapter discusses organizational and procedural problems. These two chapters will be of most interest to the layman and to the average executive whose use of mathematics is limited to the pocket slide rule. The remaining chapters deal fairly exhaustively with the calculus methods used in the solution of typical problems. These will be most valuable to the scientists analyst and will permit him to start on the shoulders of World War II experience. Other valuable data contained in the book are the mathematical tables that have been appended, an exhaustive bibliography, and an extremely helpful index.

In this air-atomic age when both physical and social events, which may affect the existence of a race, are occurring at an ever increasing rate, all of our thoughts, actions, and operations must be geared-up in proportion. What may be final decisions will have to be made in a hurry. Proper use of operations research methods can beneficially influence both the speed and quality of these decisions. Professors Morse and Kimball have made a notable contribution to the art of management and, indirectly, to our national security. Their conscientious work deserves the highest commendation.

HOWARD M. MCCOY
Colonel, U.S.A.F.

Mathematics of Relativity

By G. Y. Rainich. New York, John Wiley & Sons, Inc., 1950. 175 pp. $3.50.

Books and essays on the theory of relativity vary in substance from the completely elementary, "The Universe and Dr. Einstein," by Lincoln Bartlet, *Harpers Magazine*, April, 1948, to the original, difficult, writings of the sage of Princeton.

Professor Rainich's book fills a gap since it stresses the preliminary and current mathematical aspect of the subject. His premise is that real understanding of relativity is impossible without the appreciation and knowledge of certain mathematical truths that are rarely a part of the undergraduate curricula of the engineer and physicist. Mathematical operations, as described by Professor Rainich, are similar to the ones used in super- and hypersonics and in control servosystems. Thus the book fulfills a practical purpose, serving as a guide to advanced mathematics for physicists. It is, of course, mandatory for those who are seriously interested in the theory of interplanetary travel.

Five chapters comprise the 170-page book. "Old Physics," Chapter I, reviews fundamental and orthodox laws of physics, but, in the very beginning, reference to vector and tensor analysis is made. These mathematical aids receive a complete treatment in the second chapter, "New Geometry." The explanation of what

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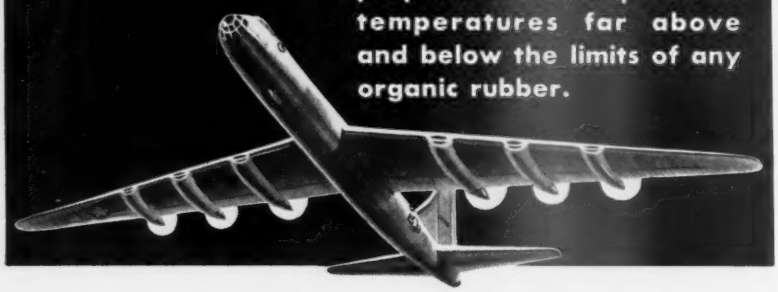

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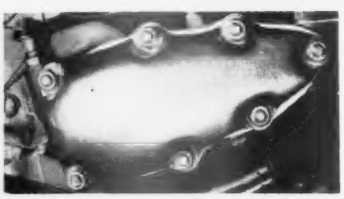

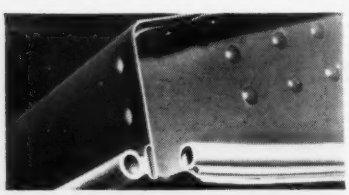

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a tensor is, of what can be accomplished by using tensor notations, and of the physical significance of the tensor is done with great skill and pedagogic maturity. In the third chapter, the author explains special relativity and goes thoroughly into the Lorenz transformation, which reduces the distances and times observed on moving systems to the condition of the stationary observer keeping the velocity of light constant for all observers. This is one of the fundamental tenets of the Einsteinian concept of the universe, and Professor Rainich's interpretation is elegant, to say the least.

Chapter 4, "Curved Space," is extremely concise, and occasionally one has to pause and realize that there are two aspects of this theory—a purely geometric one (collateral reading, *Differential Geometry*, by Eisenhard, Princeton University Press) and a physical one. In the fifth and final chapter, the author returns to general relativity and, in addition to the analysis of other phenomena, makes a remarkable comparison of the Newtonian motion of a planet and the relativity motion of a planet.

A one-page conclusion terminates this work on a cadenza of philosophy where the author says, "The question whether there is such a thing as truth —what does actually happen—is not considered in this book."

To the engineers and physicists engaged in advanced work, this book is highly recommended since it promotes thinking. The book, despite its serious title, is easily read, and the contents are readily assimilated.

DR. STEPHEN J. ZAND
Vice-President in Charge of Engineering
Lord Manufacturing Company

Guided Missiles: Rockets and Torpedoes

By Frank Ross, Jr. New York, Lothrop, Lee & Shepard Company, Inc., 1951. 186 pp., illus. $2.75.

The guided missile is the new vogue. Though it may be solid or liquid propelled, jet or ram-jet propelled, or even propelled by conventional propellers—as long as it is (1) unmanned and (2) capable of some kind of internal or remote control to assist it to its destination, it falls within the broad scope of guided missiles described in this book.

Writing in an easy expository style for the same 'teen-age reading public that he introduced to the subject with his earlier *Young People's Book of Jet Propulsion*, Mr. Ross tells as much of the story of current developments in *Guided Missiles* as can be gleaned from the official releases and published news and reports. While many of the developments and illustrative photographs will prove familiar, the fact that such a compilation can already yield a total of over 70 known foreign and American missiles will

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come as a surprise to those who have not followed the subject closely.

Since little is obtainable on this subject in book form, *Guided Missiles* will be welcomed for bringing the scattered record of available historical and descriptive material together within the covers of one book. While it is regrettable that annotations covering source material and the usual subject index one expects even in a nontechnical work on a scientific subject are missing, this book should be a handy reference to what can and has been told.

The book is divided into six chapters, the first of which briefs the historical background from thirteenth-century Chinese rockets to early twentieth-century concepts of a guided missile. Definitions and basic principles give a general idea of guidance methods, which include such examples as the "Pre-Set," "Command," "Beam Rider," "Homing," and "Star Guidance" systems.

The intensive German missile development during World War II is summarized in the second chapter. In addition to the well-known V-1 and V-2 "vengeance" pulse-jet and rocket weapons, some of the less publicized ones such as the Rheinbote, Natter, and Beethoven Apparatus, among the scores of such weapons, are described and illustrated.

While American missile pioneers were active as far back as World War I, when the concept of a long-range robot air weapon was established and scientific studies of the solid-propellant rocket were well under way, their efforts were not given the lavish support accorded the German missile scientists and engineers. Nevertheless, substantial progress was made, and Chapter III goes on to tell about the Kettering-Sperry remote-controlled flying bomb of 1916; the fundamental researches of Dr. Robert H. Goddard from 1907 to 1945; and the American missiles such as the "Gargoyle," "Loon," "Robin" (with the television eye), "Tarzon," and the "Weary Willies."

A few of these missiles were frankly reproductions or improvements on the German types. A survey of the status of development and the ever-widening goals led the Armed Forces into a new phase of postwar missile developments, which Mr. Ross discusses in Chapter IV. Here one finds the available data on missiles announced more recently in the public press—e.g., the Air Force "GAPA" (ground-to-air pilotless aircraft) and "Firebird"; the Navy "Bumble Bee," "Viking," and "Aerobee"; the Army WAC-Corporal V-2 250-mile-altitude record holder; the N.A.C.A. "Tiamat"; and many others.

The fifth chapter attempts to cover "Missile Developments in Other Lands." This is an ambitious title since Russia's progress remains an enigma. The tally becomes necessarily reduced to the too meager report of only the British "Queen Bee"

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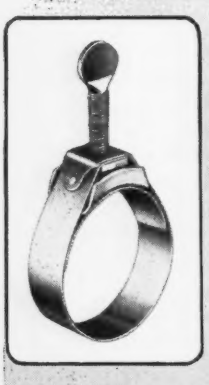

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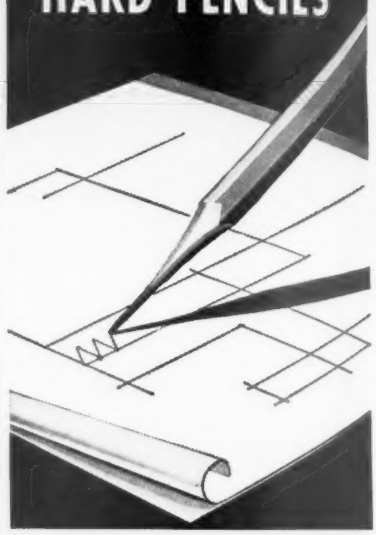

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and "Stooge" missiles and the Japanese "Baka." The final chapter directs attention to the possibilities of some of the newest designs such as the 500-mile-range "Matador," the ground-to-air interceptor "Loki," and the submarine-seeking "Oriole" and concludes, in a weaker vein, on the delights and difficulties of nonmilitary "satellite" and "moon" rockets.

Sensational and exaggerated publicity given to developments in this field a few years ago led to the natural cynical reaction—"we have the push button." Mr. Ross shows that the present progress is well beyond the "push-button" stage and justifies a look ahead. In any case, regardless of how he or this reviewer may personally feel about the future of guided missiles in war and in peace, the *raison d'être* of this book is that its publisher is convinced that a great many people, especially young people, want to know about it. Whether or not we may believe that these missiles will overshadow all present weapons and their carriers, we are all, young and old, bound to keep informed on the progress in the new field.

Guided Missiles fulfills this general objective well, is recommended as readable, and is certainly useful, with its 100 half-tone illustrations, to those contemplating engaging in this challenging work but who do not yet have an acquaintance with the new jargon of names and the background of data that they will surely encounter.

ALFRED AFRICANO
Staff Engineer
Rocket Department
Propeller Division
Curtiss-Wright Corporation

Book Notes

AERODYNAMICS

The Physical Nature of Flight. Ray Holland, Jr. New York, W. W. Norton & Company, Inc., 1951. 287 pp., illus. $4.00.

The purpose of this book is to describe the physical principles of airplane flight for the layman. Mr. Holland has succeeded admirably. Mathematics is not used, though formulas are occasionally suggested, using words instead of symbols. Word-pictures, anecdotes, and examples are used, examples being taken from familiar situations. Illustrative examples of flying or design problems are from the author's own experience. The sketches are plentiful and well captioned. There are 24 chapters, proceeding from The Flight of a New Airplane in Chapter 1 through The Atmosphere, Newton's Laws, Lift, Drag, Impact, and Friction to final chapters on Stability, Better Flight Control, Flight Efficiency, and How Fast? All aspects of the physical basis of flight are covered, including pressures, negative pressures, the vortex, flow separations, the stall, wing sections and streamlining, propulsion, and the compromises in a flying machine. Mr. Holland is a Research Associate at the New Mexico Military Institute and was formerly in charge of Aerodynamics, Wind Tunnel and Flight Test, Lockheed Aircraft Corporation, Factory A.

AIR TRANSPORTATION

World Airline Record, 1950-51 Edition. Chicago 4, Ill., Roy R. Roadcap & Associates, 1951. 263 pp., maps. $9.75.

About 75 per cent of the world's scheduled airline service, or 102 air lines, is covered in this volume. It continues and expands the two previous editions, covering the traffic, operations, and finances of all U.S. certificated air lines, and a number of foreign air lines. For each air line, its routes, history, description and management, income accounts, pay-load and income account analysis, balance sheets, capitalization and financial ratios, and a historical financial summary covering usually seven years are given. Feeder lines and freight carriers are included. In the first 48 pages, a general survey of air-line development is presented with statistical tables and maps.

The Transportation Industries, 1889–1946, a Study of Output, Employment, and Productivity. Harold Barger. New York, National Bureau of Economic Research, Inc., 1951. 288 pp., diagrs. $4.00.

Data for the transportation industry as a whole and for steam railways, electric railways, pipe lines, waterways, and air lines provide for a comparison between types of transportation and a basis for the study of trends in the field. Data for contract air carriers were not available in sufficient detail for statistical assessment of their significance in the total picture. The same is true of the privately owned passenger cars and trucks, the two most numerous additions to the transportation field since 1889 and the two responsible for changes affecting more people. The rapid increase in passenger and freight service by air since 1946 makes supplementary studies necessary in order to follow the latest trends. However, this book performs a notable service in bringing together and correlating available data, particularly in regard to waterways and pipe lines so that a convenient starting point for further studies is provided.

Boxcars in the Sky. Richard Malkin. New York 4, N.Y., Import Publications, Inc., 1951. 288 pp., illus. $4.75.

The present status of air cargo is related in nontechnical style, covering, in the first nine chapters, the principal types of cargo being shipped by air: produce, publications, animals, cattle, seafood, fashions, flowers, and assorted other types. The remaining 13 chapters deal with various aspects of the cargo picture, both civil and military operations being considered. Considerable information on specific actual operations is reported, and the book offers an informal summary of the history and trends of air cargo throughout the world. Statistics are not presented, and it is likely that an overall statistical picture is not possible because of lack of data. Sources are indicated in footnotes.

AIRPLANE DESIGN

British Civil Airworthiness Requirements: Section C, Engines and Propellers. London, Air Registration Board, 1951. 84 pp. 4*s*.

British Civil Airworthiness Requirements: Section D, Aeroplanes. London, Air Registration Board, 1951. 214 pp. 7*s*. 6*d*.

AIRPORTS

Proceedings, Conference on Ground Facilities for Air Transportation, Cambridge, Mass., Massachusetts Institute of Technology, September 12, 13, 14, 1950. Co-sponsors, The Port of New York Authority, Civil Aeronautics Administration, Massachusetts Aeronautics Commission. Cambridge 39, Mass., Prof. A. J. Bone, Room 1-349, Massachusetts Institute of Technology, 1951. 225 pp., illus., diagrs. $2.00.

Contents: Welcome to Conference, John B. Wilbur. Conference Objectives, Jerome C. Hunsaker. The Airport As a Factor in Airline Efficiency, George H. Clay. Airport Requirements for Future Aircraft, W. T. Dickinson and R. Dixon Speas. Forecasting Air Traffic Potentials, D'Arcy Harvey. Air Freight, Chester H. Chiodo. Ground Facilities Required by Local Air Services, Joseph Garside. Runway Configurations—The One-Directional Airport, Paul H. Stafford, William P. Becker, and John H. Geisse. The Place of Private Safety Organizations in Airport Operations, Jerome Lederer. Does Your Town Need an Airport—If So, How Big, W. E. Cullinan, Jr. Site Planning the Airport Terminal Area, Melvin B. Borgeson. The Effect of Airport Management on Airport Design, Leigh Fisher. Coordination of Airport Design and Airport Development, D. W. Nyrop. Landing Places for Small Aircraft, Otto C. Koppen and W. T. Piper. Terminal Buildings for Small Airports, Harold C. Knight. Adequate Highways to Airports Important in Aviation Development, Walter R. Macatee. Helicopter Service to Airports, J. Burleigh Cheney. How Can Air Travel Be Made Easier and Faster, Charles Froesch. Recent Development of Corps of Engineers in Airport Pavement Design, Gayle McFadden and Thomas B. Pringle. Research in Chemical Stabilization of Soils, T. William Lambe. Functional Design of Airport Terminal Buildings, Thomas M. Sullivan. Airport Lighting and Electrical Systems, Martin A. Warskow. Functional Design of Hangars and Shops, Robert Kerr, Jr. Ground Operations Are Costly—How Can They Be Improved, N. D. Boratynski. London Airport Ground Movement Studies, W. A. Mortimer. Loadair, H. W. Anderson. Air Cargo Handling Methods, L. R. Hackney. Observations Relative to the Planning and Building of Airports, Miles N. Clair. Terminal Building Layouts in Foreign Countries, J. M. Kyle. America's Main Streets of Aviation, Jennings Randolph. Contribution of Engineering College to Air Transport Training, A. J. Bone. Air Traffic Control and Time Utilization, D. E. Olshevsky.

ELECTRONICS

Electronics. P. Parker. London, Edward Arnold & Company; New York, Longmans, Green & Company, 1951. 1,050 pp., diagrs. $10.

Based on lectures given at the Northampton Polytechnic, this comprehensive book presents the point of view of a physicist interested in applications of electronics. It is intended to provide a background for the circuit specialist and a starting point for the tube specialist. The physical action of electronic devices is emphasized, but the basic circuit work is covered. A knowledge of basic physics, calculus, and alternating currents is required of the reader. The author is Senior Lecturer in Physics at the Northampton Polytechnic in London.

FLIGHT SAFETY & RESCUE

Survey of Research Projects in the Field of Aviation Safety. Harry F. Guggenheim, Chairman, Foundation Committee; Theodore P. Wright, Chairman, Executive Committee; Jerome Lederer, Director; Ruland M. Woodham, Administrator. New York, Daniel & Florence Guggenheim Aviation Safety Center at Cornel University, 1951. 62 pp. $1.00.

About 1,600 research projects are described, with indications of the laboratories, Government agencies and organizations carrying out the research. The arrangement is according to major headings of the Standard Aeronautical Indexing System, with particular emphasis on Air Transportation, Aircraft Instruments, Airplane Design, Airports & Airways, Accident Prevention and Protection, Aviation Medicine, Comfortization, Electronics, Navigation, Operating Problems, and Power Plants. Projects are listed also under Aerodynamics, Flight Testing, Fuels and Lubricants, Meteorology, Military Operations, Propellers, and other related subjects. Gaps and additional research required on aircraft, the air, and the operator are discussed in the introduction.

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FUELS & LUBRICANTS

A.S.T.M. Manual on Measurement and Sampling of Petroleum and Petroleum Products. Philadelphia, American Society for Testing Materials, 1950. 120 pp., illus., diagrs. $2.00.

A.S.T.M. methods of gaging, temperature measurement, sampling, a recommended practice for volume calculations and corrections, tests for water and sediment by centrifuge and gravity by hydrometer, and a proposed method of sampling liquefied petroleum gases are among the topics discussed.

Physical Constants of Hydrocarbons Boiling Below 350°F. (Special Publication No. 109.) Philadelphia, American Society for Testing Materials, 1950. 16 pp. $1.00.

Data are given on 225 compounds in six classes of hydrocarbons, including name of compound, formula, molecular weight, boiling point, vapor, pressure, freezing point, the three critical constants, liquid densities, gas density, specific heats, calorific values, heats of vaporization, refractive index, air required for combustion, inflammability limits, aniline point, and octane number. The values presented in the tables represent those published up to May, 1950.

INSTRUMENTS

Introduction to Servomechanisms. A. Porter. London, Methuen & Company, Ltd.; New York, John Wiley & Sons, Inc., 1951. 154 pp., diagrs. $1.75.

The theoretical foundations of servomechanisms are outlined with emphasis upon such basic design problems as adequate damping and small dynamic lags. The mathematical treatment is essentially classical. The use of the Laplace transformation is avoided, since the book is addressed to scientists and engineers who do not intend to specialize in servomechanisms and who are interested in physical principles rather than mathematical techniques. The author is Head of the Research Department of Ferranti Electric, Ltd., of Toronto. This volume is based on a course of lectures given at the Military College of Science in Shrivenham, England.

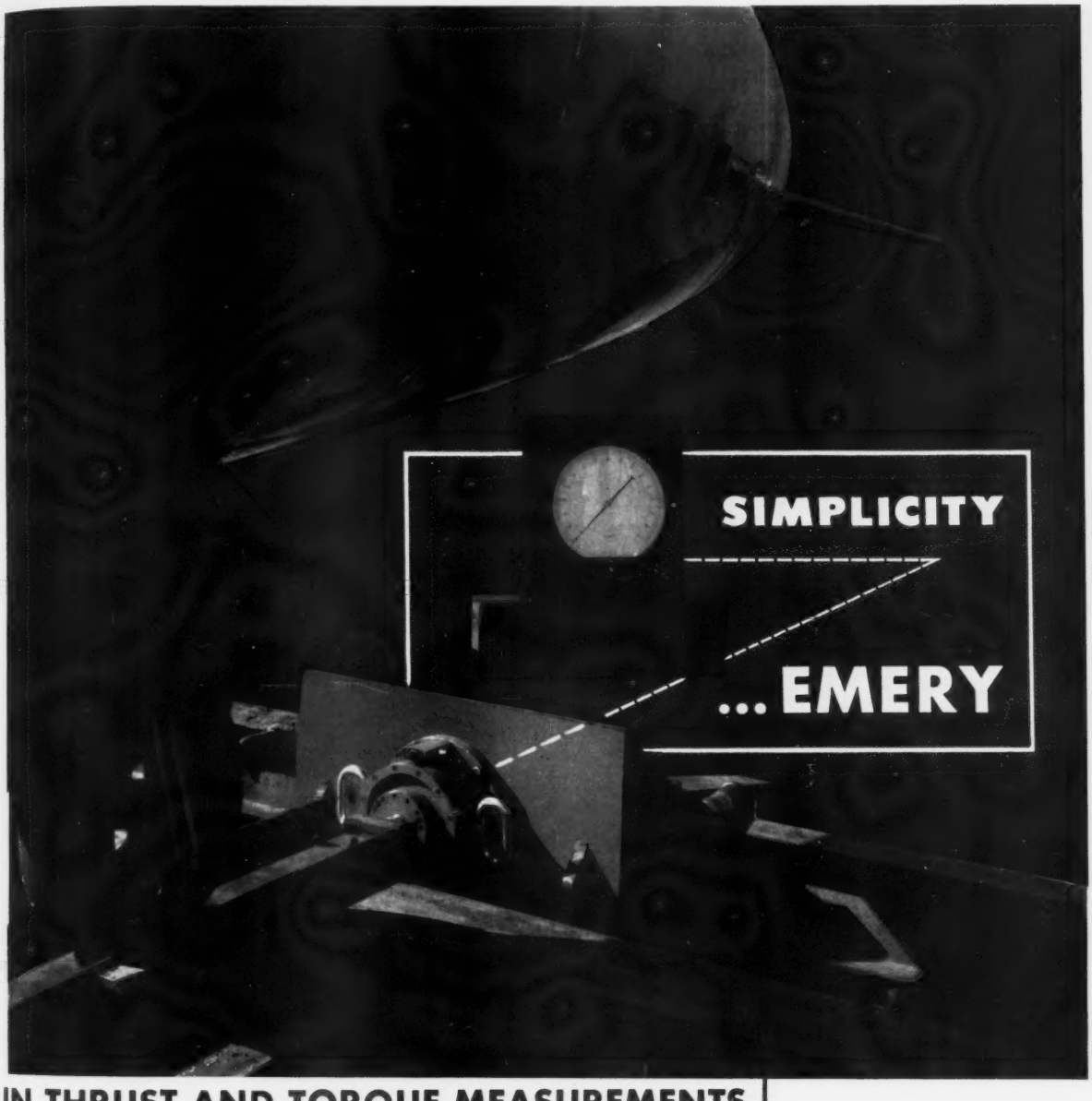
Flow Measurement with Orifice Meters. Reid F. Stearns, Russell R. Johnson, Robert M. Jackson, and Charles A. Larson. New York, D. Van Nostrand Company, Inc., 1951. 350 pp., diagrs. $7.50.

Compiled by research associates of the Standard Oil Development Company, this book is intended mainly for engineering, technical-service, and instrument groups concerned with petroleum refinery operations, and it provides an excellent reference for the use of fixed-area orifice meters in that application. The principles and basic methods are sufficiently general to be applicable as guides for fluid metering in other industries. Flow equations are presented in convenient form, and flow data are given in 160 illustrations and charts and 26 tables. Sources for all data are included in the bibliography.

MACHINE ELEMENTS

Guillet's Kinematics of Machines. Austin H. Church. 5th Ed. New York, John Wiley & Sons, Inc., 1951. 299 pp., diagrs. $4.00.

In this new edition of Professor George L. Guillet's textbook, last revised in 1940, Chapter 4 on Velocity and Acceleration in Plane Motion has been largely rewritten with expanded treatment of the material on image methods and the addition of a treatment of Coriolis' acceleration. Chapter 8 on Gears has been revised to emphasize the currently used generating principle of producing gear teeth. Articles on simple harmonic motion, on the scale determination for the velocity and acceleration curves, on the inversions of the slider-crank mechanisms, and on the proof of Klein's construction have been revised. Chapter 6 on Cams has been extensively revised. New material on the use of the tabulation method for locating instant centers and for epicyclic gear trains has been added. Footnote references lead to more detailed discussions of new material. Professor Church teaches mechanical engineering at New York University.



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MANAGEMENT & FINANCE

Human Relations in Industry. Burleigh B. Gardner and David G. Moore. Rev. Ed. Chicago, Richard D. Irwin, Inc., 1950. 431 pp., diagrs. $6.65.

This is a rewritten and expanded edition of a book originally published in 1945, going beyond the considerations of the internal structure of industry in the earlier edition. More analysis of different types of organization and of the effects of executive personality upon the organization, the structure of union organization, the wider social aspects of industrialization, social class trends in America, the effects of mass production techniques on the individual employee, and the relation of industry to the community are some of the additions made to the discussion. The various parts of the book take up The Structure of the Organization (203 pages), The Employee in the Organization (104 pages), Changes Affecting the Organization (20 pages), and Management in the Organization (65 pages). The senior author is Executive Director, Social Research, Inc., and both authors are lecturers at the University of Chicago.

MATERIALS

Titanium: Report of Symposium on Titanium. Sponsored by Office of Naval Research, December 16, 1948. Washington, U.S. Govt. Printing Office, 1949. 157 pp., illus. $0.65.

Contents: The Bureau of Aeronautics' Titanium Program, N. E. Promisel. The Program of the Air Materiel Command on Titanium Alloys, Richard R. Kennedy. The Titanium Program of Army Ordnance, Laurence S. Foster. Production of Titanium Powder at Boulder City, F. S. Wartman. Fabrication of Titanium and Investigations of Titanium-Nickel Alloys in the Bureau of Mines Laboratories, J. R. Long. Physical and Mechanical Properties of Commercially Pure Titanium, C. I. Bradford, J. P. Catlin, and E. L. Wemple. Production and Properties of Iodide Titanium, Bruce W. Gonser. Properties of Iodide Type Titanium, F. B. Litton. Induction Melting of Titanium Metal in Graphite, J. B. Sutton. The Production and Arc Melting of Titanium, C. T. Greenidge and L. W. Eastwood. Some Preliminary Tests to Determine Applications for Titanium, W. Lee Williams. Some Preliminary Data on Alloys of Titanium, E. I. Larsen, E. F. Swazy, L. S. Busch, and R. H. Freyer. Titanium-Base Alloys, Howard C. Cross. Some Aspects of the Metallurgy of Titanium Alloys, P. H. Brace. The Titanium-Base Alloys Program of the Naval Research Laboratory, E. J. Chapin. The Carbon-Oxygen Relationship in Titanium Melted in Carbon Refractories, S. F. Urban and A. C. Haskell. First Progress Report on Titanium-Carbon and Titanium-Nitrogen Phase Diagrams, J. P. Nielsen.

Alcoa Aluminum and Its Alloys. Pittsburgh, Aluminum Company of America, 1950. 178 pp., illus.

Properties, wrought products and shapes, general design and choice of alloys for castings, and fabricating practices are included.

Mechanical Fastening Methods for Aluminum. Louisville, Ky., Reynolds Metals Company, 1951. 136 pp., illus., diagrs.

Rivets, screw fasteners, nails and pins, metal stitching, mechanically formed joints, and resin bonding are included.

Bibliography on Plasticity, Theory and Application. Compiled by Dimitri Kececioglu. New York, American Society of Mechanical Engineers, 1950. 191 pp. $2.25.

This useful list includes 1,845 articles, published between 1841 and July 7, 1949, and 40 books. There is a detailed alphabetic index to the articles, covering 14 pages and referring to theoretical concepts, metals, properties, manufacturing processes, and test methods. An author index is provided. About 70 per cent of the material listed was published after 1935. Titles are given in English in most cases, with a statement of the original language of the article. This compila-

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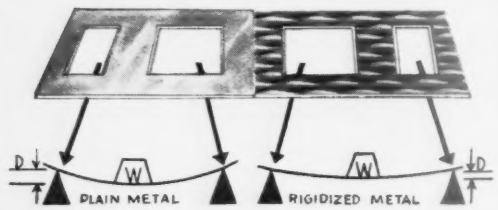

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tion offers an excellent survey of the literature of plastic deformation, plastic flow, and stress distribution in metals.

METEOROLOGY

Workbook for Weather Forecasting. E. S. Pulk in collaboration with E. A. Murphy. New York, Prentice-Hall, Inc., 1950. 66 pp., illus., maps. $5.00.

Intended to supplement textbooks on meteorology, this laboratory workbook contains chapters on weather analysis and weather forecasting, and discussions and plotting exercises on the surface station model and upper-air station models. The airway observation code is presented with exercises, and there is a discussion of the synoptic weather chart series. A map kit for use in the exercises is included. Mr. Pulk is Instructor in Meteorology, and Mr. Murphy is a Technical Instructor in Meteorology; both are at the Massachusetts Institute of Technology.

Cloud Physics. D. W. Perrie. New York, John Wiley & Sons, Inc., 1950. 119 pp., illus. $4.50.

The first half of this book is concerned with the description and naming of cloud forms, large-scale processes responsible for their formation, and their internal physics, including nuclei of condensation and sublimation and natural and induced precipitation. Applications of this basic information are discussed in the last five chapters, including cloud observations, forecasting applications, clouds in relation to flying, stratosphere clouds, and optical and electrical phenomena. A bibliography of 160 papers for the specialist and a glossary of terms are included. The author is a meteorologist with the British Columbia Forest Service.

POWER PLANTS

Proceedings of the 21st National Oil and Gas Power Conference, Chicago, April 25-29, 1949. New York, American Society of Mechanical Engineers, 1951. Various paging, illus., diagrs. $3.00.

Contents: Dynamic Analysis of Valve Springs and Vibrations in Valve Mechanisms, Troels Warming. Effect of Cylinder Pressure Rise on Engine Vibrations, J. O. Hinze. Two-Cycle Dual-Fuel Diesel Engine with Automatic Fuel Conversion, E. L. Conn, R. H. Beadle, and G. A. Schauer. Diesel Locomotive Engine Cooling Systems, F. H. Brehob. Ignition System for Oil Engines, H. B. Holthouse. A Training Program for Railroad Personnel, George V. Taylor. Diesel-Engine Maintenance Instruction, ALCO V Type Engine, S. E. Lodge.

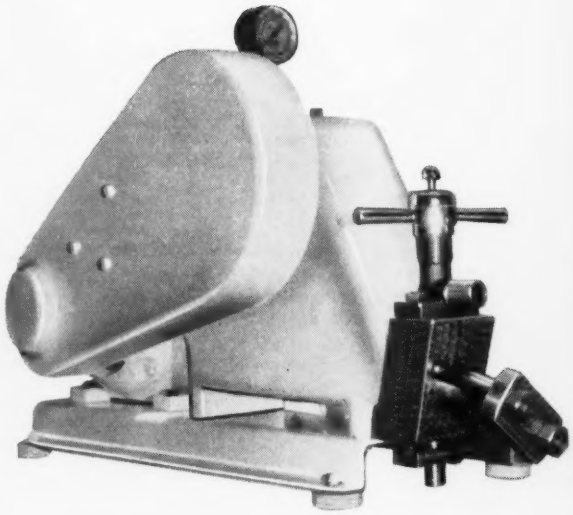
PRODUCTION

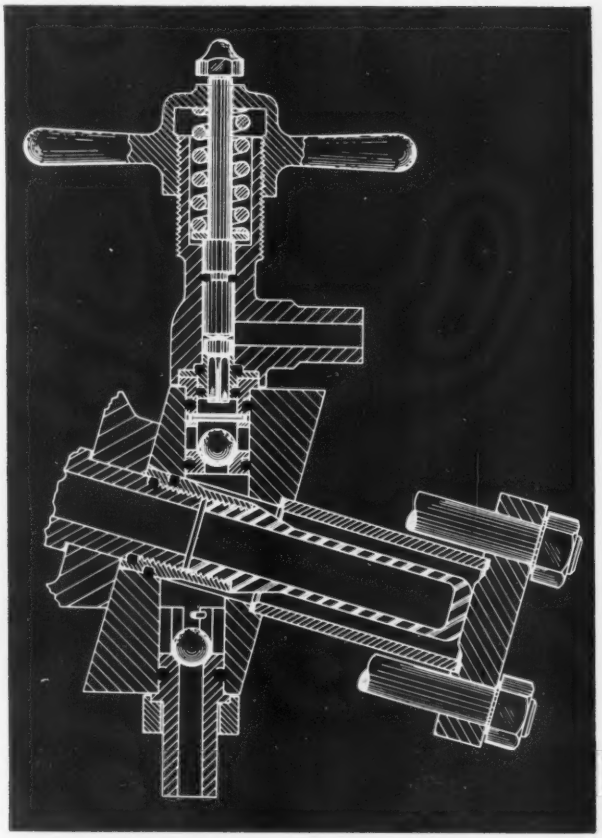
The Navy and the Industrial Mobilization in World War II. Robert H. Connery. Princeton, N.J., Princeton University Press, 1951. 527 pp. $6.00.

This study was undertaken at the request of James G. Forrestal as Under Secretary of the Navy and was continued under his successor in that post, W. John Kenney. While the author, a Professor of Public Administration at Duke University, had full access to official records, the book is an independent study and not an official history. It covers the development of full-scale Navy-civilian cooperation on contracts, prices, controlled materials and man power, financing, plant expansion, priority scheduling, and other problems involved in the production of World War II ships and aircraft.

Plant Layout, Planning and Practice. Randolph W. Mallick and Armand T. Gaudreau. New York, John Wiley & Sons, Inc., 1951. 391 pp., illus., diagrs. $7.50.

This book is intended for the administrative executive and the plant engineer and as an engineering and business school text. An organized science of plant layout for both new and existing plants is presented, integrating production operations with their related service operations such as receiving, handling, storing, and transportation of materials, inspecting, shipping, re-





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pairing, and office work. The authors' aim is to present ways to keep service costs equal to direct production costs. Engineering techniques are presented for determining plant capacities, balancing machine operations, and equipping work stations; designing production and assembly lines, receiving, shipping and storage areas, dispatch stations, toolrooms, materials handling systems, and office space; evaluating capital outlays for plant and equipment, operating costs, and methods of presentation of proposals. The discussion is based on 25 years of industrial practice and is supported by an excellent bibliography of books and articles. The senior author is an Executive Staff Engineer with the Westinghouse Electric Corporation, and Mr. Gaudreau is a Management Consultant with Gaudreau, Rimbach, and Associates, in Pittsburgh.

Technical Drafting Essentials for Vocational and Technical Students. Warren J. Luzadder. New York, Prentice-Hall, Inc., 1950. 326 pp., diagrs. $4.00.

Considerable material in this text has been taken from the author's larger book, *Fundamentals of Engineering Drawing*. The first half of the book is devoted to such fundamentals as lettering, geometry, multiview drawing, dimensioning, pictorial drawing, sketching, and drawing instruments and their use. Later chapters take up the preparation of working drawings, both detail and assembly, topographic drawings, the construction of charts and graphs, and applications to screw threads, fasteners, welding, piping, gears, cams, sheet metal, and structures. The author is an Associate Professor of Engineering Drawing at Purdue University.

British Standard for the Assessment of Surface Texture; Centre-Line-Average Height Method. (B.S. 1134:1950.) London, British Standards Institution, 1950. 52 pp., diagrs. 6*s*.

The measurement of the irregularities of metal surfaces machine-finished by various methods is outlined, including terminology, instruments and methods, preferred limits for the grading of surface texture by means of index numbers, and symbols for expressing surface textures on drawings.

REFERENCE WORKS

HANDBOOKS

Mechanical Engineers' Handbook. Edited by Lionel S. Marks. 5th Ed. New York, McGraw-Hill Book Company, Inc., 1951. 2,236 pp., diagrs. $15.

This standard handbook was last revised in 1941. The present edition includes new or greatly revised material on the theory of fluid mechanics, elastic and plastic deformation of materials, stresses in turbine discs, transonic and supersonic aerodynamics, jet propulsion, rockets, radar, and television. New and revised material on processes includes radiant heating, heat pumps, modern casting methods, industrial supersonics, machining of plastics, automatic process control, and statistical quality control. Ferrous and nonferrous alloys, high-temperature alloys, plastics, silicones, adhesives, explosives, rocket fuels, and powder metallurgy are topics on materials extensively revised, and gas turbines and atomic power constitute new sections on power sources. There are more than 75 contributors, including William Bollay, Frank W. Caldwell, Ward F. Davidson, J. P. Den Hartog, W. S. Diehl, Howard W. Emmons, E. N. Fales, W. H. McAdams, E. L. Robinson, and George F. Wislicenus.

The Practical Engineer Pocket Book, 1951. Edited by N. P. W. Moore. London and New York, Pitman Publishing Corporation, 1951. 744 pp., diagrs. $3.00.

Engineering data are presented briefly in 22 chapters, including Pipes, Beams, Columns, Springs, etc.; Friction and Power Transmission; Cranes and Lifting Tackle; Pyrometry; Metallurgy; Steam (6 chapters, including steam turbines); Gas and Oil Engines; Gas Turbines; Air Compressors; Air and Ventilation; Hydraulics; Machine Tools; Modern Lubrication; Welding and Cutting; and Unified Screw Threads. Technical terms in German, Spanish, and French and a list of technical journals are included.

RESEARCH

Proceedings of the Fourth Annual Conference on the Administration of Research, University of Michigan, September 11–13, 1950. Ann Arbor, Mich., University of Michigan Press, 1951. 91 pp., diagrs. $3.00.

Contents: Calculated Risk, Its Place in the Selection, Control, and Termination of Research Projects, T. H. Vaughn, E. D. Reeves, D. H. Loughbridge. Measuring the Return from Research, Allen Abrams, W. S. Parsons, C. G. Suits. Engineering Research in Modern Corporations, J. C. Zeder. What Is Needed in a Research Executive, J. C. Flanagan, A. E. Lombard, Jr., R. D. Stevens. Overhead As a Factor in Sponsored Research, W. K. Pierpont. New Government Services to Research: National Science Foundation, T. J. Killian. Building Research, R. U. Ratcliff. Research for Small Industry, J. C. Green. Summary of Conference, E. A. Walker.

SCIENCES, GENERAL

GEOGRAPHY

Geography of the USSR, a Regional Survey. Theodore Shabad. New York, Columbia University Press, 1951. 584 pp., maps. $8.50.

The greater part of this book is concerned with the geography of some 65 administrative areas of Russia, including areas awaiting final settlement of the Japanese and German peace treaties. It is based largely on data of the 1946–1950 Five Year Plan, as reported in Russian newspapers, periodicals, and books. Under this plan, air lines were to reach 110,000 scheduled miles by 1950. Aircraft factories are reported in the book when known, but Russian security classified data on such industries as aircraft and atomic energy must necessarily be inferred largely from the general geographic picture. This book offers an excellent general picture, supported by 55 maps and a selected bibliography. There is an index of about 4,600 place names.

MATHEMATICS

Dimensional Analysis and Theory of Models. Henry L. Langhaar. New York, John Wiley & Sons, Inc., 1951. 106 pp., diagrs. $4.00.

The first three chapters develop the principles of dimensional analysis systematically, with examples, introducing Buckingham's theorem without using the pi notation. In Chapter 4 the logic and scope of the subject are discussed rigorously, with proofs of the theorems, on a level too abstract and mathematical for most undergraduate engineering students, who can omit it if they so desire. Theories of similarity and model testing are taken up in Chapter 5. Applications of dimensional analysis to problems of stress and strain, fluid mechanics, heat transfer, and other thermal problems, and electromagnetic theory are discussed in Chapters 6, 7, 8, and 9. The final chapter illustrates the method of deriving model laws from the differential equations governing particular phenomena. The author is a Professor of Theoretical and Applied Mechanics at the University of Illinois.

Infinite Matrices and Sequence Spaces. Richard G. Cooke. New York, The Macmillan Company, 1950. 347 pp. $6.50.

This is the first complete study of infinite matrices to be published. The theory is developed with special reference to the summability of divergent sequences and series (from various points of view) and is concerned with the behavior of infinite matrices in general or of classes of them. Special matrices well known in summability are mentioned briefly or are referred to in the extensive bibliography. Various links of infinite matrices with the theory of functions, modern algebra, topology, quantum mechanics, and spectral theory are brought out in the later chapters. Further applications are planned in a projected second volume. The author is a Reader in Pure Mathematics at the University of London.

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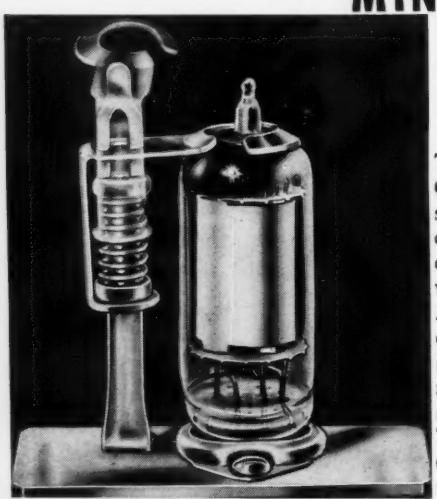

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Jacobian Elliptic Function Tables. L. M. Milne-Thomson. New York, Dover Publications, Inc., 1950. 132 pp. $2.45.

The tables, formulas, and graphs presented cover a wide range of applications and include complete elliptic integrals, series, double and half arguments, change of parameter, approximations, differentiation, elliptic integrals of the first, second, and third kind, and conformal mapping. Five-figure tables of the elliptic functions sn u, cn u, and dn u, an eight-figure table of the complete elliptic integrals K, K', E, E', and the Nome q, and a seven-figure table of the Jacobian Zeta-function $Z(u)$ are included. Professor Milne-Thomson teaches mathematics at the Royal Naval College in Greenwich, England.

The Fourier Integral and Certain of Its Applications. Norbert Wiener. New York, Dover Publications, Inc., 1951. 201 pp. $3.95.

This is a reprint of Professor Wiener's monograph, originally published in 1933, in which he demonstrated new techniques for the use of the Fourier integral in both statistics and analysis.

Advanced Mathematics for Technical Students. Part II. H. V. Lowry and H. A. Hayden. London and New York, Longmans, Green & Company, 1950. 422 pp., diagrs. $3.75.

Methods and results in differentiation and integration of a general nature are taken up in the first chapter, and the following chapters include discussions of envelopes, first-order differential equations, forced mechanical and electrical oscillations, recurrence relations, determinants, coordinates of a point in space, spherical triangles, differentiation and integration of functions of several variables, Fourier series, motion of a system of particles and a rigid body, energy methods, and infinite series. This is the second volume of a three-volume work. The authors are Heads of the Mathematics Departments of the Woolwich Polytechnic and Battersea Polytechnic, respectively.

MECHANICS

A Second Course of Mechanics and Properties of Matter. A. E. McKenzie. Cambridge and New York, Cambridge University Press, 1950. 232 pp., illus., diagrs. $2.50.

The first three chapters furnish a summary of the principles of statics, hydrostatics, and dynamics, written from the physical point of view. The next chapters take up Simple Harmonic Motion, Gravitation, Elasticity, Surface Tension, and Viscosity and Lubrication. The kinetic theory of gases is omitted. The author is associated with Trinity College at Cambridge University.

PHYSICS

Quantum Mechanics. Alfred Landé. New York, Pitman Publishing Corporation, 1951. 307 pp., diagrs. $5.50.

In this college textbook the physical background of quantum mechanics and its close relation to classical experience are emphasized. The transitory character of present theories is presented by frequent allusions to the historical development. A rigid axiomatic formulation of the mathematical method is avoided, though considerable attention is given to approximation methods, matrix mechanics, and quantum statistics. A bibliography of about 65 books is included. The author is a Professor of Physics at the Ohio State University.

SPACE TRAVEL

A Handbook of Space Flight. Wayne Proell and Norman J. Bowman. Chicago, 10630 S. Saint Louis Ave., Perastadion Press, 1950. 185 pp. $3.50.

Tables 1 to 27 cover Properties of Materials; Tables 28 to 51, Physical Data; Tables 52 to 81, Astronomical Data, including the atmosphere; Tables 82 to 92, Rocket Data. A glossary and some data on human nutrition are included; there is also an index. Sources of the data are not given. The tables on light, pressure, potential and gravity fields, theoretical exhaust velocities, and temperature-particle velocity relationships are stated to be presented here for the first time. Since the book is intended to be of assistance to research effort on the operation and direction of a ship in space rather than on the design of a space ship, thermodynamic and engineering structural information is not included.

WATER-BORNE AIRCRAFT

ANC Bulletin, Water Loads. Subcommittee on Air Force-Navy-Civil Aircraft Design Criteria of the Munitions Board, Aircraft Committee. (ANC-3). Washington, U.S. Govt. Printing Office, June, 1950. 16 pp., diagrs. $0.15.

Procedures are described for the computation of the magnitude and distribution of the water pressures and water loads imposed on the hull or main float and the auxiliary floats of seaplanes during landing and take-off. Empirical constants, based upon the satisfactory structural performance of a number of seaplanes, are introduced in order to modify and adapt the theory of seaplane impact for practical design procedures.

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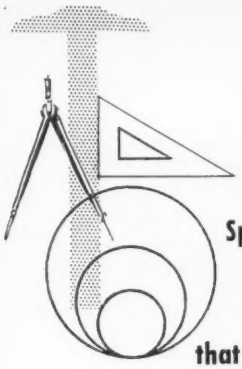

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ELECTRONICS ENGINEERS: Sonar—Development and design in the field of underwater acoustics in the sonic and subsonic portions of the spectrum. **Radar**—Development and design of radar equipment involving ultra and super high-frequency components and systems. **Radio**—Development and design of AM and FM communications, navigation, and/or radio-control systems including transmitters, receivers, antennae, etc. **Control**—Development and design of electronic circuits involving autopilots, regulating devices, servomechanisms, computers, data transmission systems, and similar devices. **Radiation**—Development in the field of electromagnetic radiation and reception for infrared, visible, and radio-frequency waves.

ENGINEERING EVALUATION—Laboratory and operational engineering evaluation and test of complete electronic aircraft systems or components thereof as listed in one or more of the options above. Design experience in the development of such components of systems is desirable.

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MECHANICAL ENGINEERS: Machine Design—Capable of making design and performance calculations and layouts of mechanisms and structural elements on aircraft components such as electromechanical mechanisms, fire-control equipment, antennae, cam, gear, and linkage systems, power drive systems and hydraulic components, general aircraft armament, and ground handling equipment. Must be capable of establishing tolerances and design details for economic production processing of such equipment. **Test and Evaluation**—Must be experienced in dynamic or operational test procedures for complete aircraft systems, or components thereof, as listed in one or more of the options above. Design experience in the development of such components or systems is desirable.

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Professors of Aeronautical Engineering—Two positions on the teaching staff of the Department of Aeronautical Engineering of The University of Texas will be available beginning September 15, 1951. These positions are described as follows. **Aircraft Structures:** Duties involve the teaching of required undergraduate courses in this field, development of advanced elective and graduate courses, further development of laboratory facilities, and supervision of graduate thesis work. Qualifications should include at least a Master's degree and preferably a Doctor's degree in aircraft structures, 10 to 15 years' experience in teaching aeronautical engineering, in industrial stress analysis work, or in a structures research laboratory. **Aircraft Design:** Duties involve the teaching of required undergraduate courses in aircraft detail design, preliminary design, and a shop laboratory course in aircraft materials and processes. This staff member would also be expected to assist in the teaching of required undergraduate courses in aircraft structures and aerodynamics and in the further development of laboratory facilities in one or both of these fields. Qualifications should include at least a Bachelor's degree and preferably a Master's degree in Aeronautical Engineering; 5 to 10 years' experience in the aircraft industry in design and/or stress analysis work; an active interest in research on design and development problems. Rank and salary for these positions will depend on previous training and experience and will range from $2,700 to $7,200 for the 9-month school year. Ample opportunities are available for individual research and for participation in sponsored research projects. Interested applicants should write to Dr. M. J. Thompson, Chairman, Department of Aeronautical Engineering, The University of Texas, Austin 12, Tex., for application forms.

301. Engineering Field Service Representative—Need man free to travel (preferably single) with engineering background and experience in gas-turbine engine test work. Field service experience desirable but not essential.

300. Design Engineer "A" and Design Engineer "B"—Responsible positions requiring 3 to 5 years' experience in mechanical design of aircraft quality, preferably in gas turbines or similar type machines. Must be capable of working from design specifications in making layouts of complete parts or components including sheet-metal construction, taking into consideration manufacturing costs, weight, stress, heat, material properties, mechanics, dynamics, and production problems.

296. Quality Control Engineer—With experience in aircraft engine or propeller manufacturing. Excellent opportunity with expanding aircraft manufacturer. Submit detailed résumé of experience and training.

294. Aerodynamicist—For position in charge of aerodynamic work on a new missile project. Should have 4 or more years' experience that has included aerodynamic stability analysis. Knowledge of supersonic flow as applied to missile design essential. Location—Detroit.

293. Communications Supervisor—Possessing air-line background, capable of being in full charge of operations communications program and electronics research and development in small air line.

The number preceding the notices represents the Box Number of the Institute of the Aeronautical Sciences to which inquiries should be addressed.

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305. Aeronautical Engineer—M.S. in Ae. and Me.E., 1924. Research, preliminary design, development. Past experience includes: Consulting Engineering (research, coordination of new developments), Project Engineer, Aerodynamics Engineer, Research Engineer, and Chief Design Engineer.

304. Engineer—M.E., M.S., 7½ years' experience in servomechanism and aerodynamic analysis and development. Directed analog computer studies. Expert in analyzing overall system dynamics.

303. Aeronautical Engineer—N.Y.U., 1934. Has held positions as designer, project engineer, chief aerodynamicist, and acting chief engineer. Experienced in wood, dural, and magnesium-alloy aircraft design; general aerodynamics, propeller controls, helicopter design, and various subordinate facets of aeronautical engineering. Desires connection in executive capacity requiring versatility with experimentally minded organization.

302. Aeronautical Engineer—(Industrial Option), B.A.E., New York University, 1949. One year's experience in machine shop and tool design (jigs, fixtures, and machine tools). Worked on U.S. Army Corps of Engineers development contract, designing mechanical operating mechanisms. Experience in aircraft design, including original layouts, detailing and modifications of existing designs. Age 25. Location—New York or vicinity.

298. Aeronautical Engineer—Eight years' experience in engineering. Seven years with major United States air line as maintenance and design engineer. Presently with large airplane manufacturer as a designer. Wishes to relocate in New York area. Experienced in all phases of aircraft maintenance engineering. Design experience on aircraft components, jigs, and tooling.

295. Aeronautical Research Engineer—B.S. in A.E. from M.I.T. Will finish this year the Alexander Hamilton Institute business course. Seven years' total experience in aeronautical research, including subsonic and supersonic wind-tunnel testing, airplane performance analysis; 4 years of guided-missile work, involving aerodynamic design, ram-jet performance, and diffuser analysis. Last 2 years spent as supervisor of guided-missile design and analysis group. Some part-time teaching experience. Excellent references. Prefers engineering position with administrative opportunities or a position where some time can be arranged to take advanced college courses.

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288. Management Executive—Age 48. M.S. in Aeronautical Engineering. Eighteen years as Naval Aviator. Extensive experience and participant in preparation of current mobilization plans and their logistic requirements. Retired with senior rank. Has been corporate officer and executive in private business since 1947, with last year in Europe. Wishes position with aviation or associated industry desiring executive experience in corporate and Government organization and management to have maximum participation in the National Defense Program.

Index to A

A

Aeronautical Engineering Catalog....93, 114
Aeronautical Engineering Review....52, 114
Air Reduction Company, Inc., Ohio Chemical & Surgical Equipment Company Division.... 66
★Airborne Accessories Corporation.... 36
AiResearch Manufacturing Company Division, The Garrett Corporation.... 4
Aluminum Company of America....41, 100
American Phenolic Corporation.... 124
Arma Corporation, American Bosch Corporation Subsidiary.... 105
Astron Corporation.... 80
Avica Corporation.... 95

B

B. H. Aircraft Company Inc.... 137
Baldwin-Duckworth Division, Chain Belt Company.. 95
Bardwell & McAlister, Inc.... 66
Bauer & Black Division, The Kendall Company.... 37
★Bendix Aviation Corporation
★Eclipse-Pioneer Division.... 121
★Scintilla Magneto Division....Inside Back Cover, 63
★BG Corporation, The.... 97
Birtcher Corporation, The.... 130
Boeing Airplane Company.... 134
★Breeze Corporations, Inc.... 43
Brush Development Company, The.... 39
Bunhill Publications Limited.... 112

C

Cal-Aero Technical Institute.... 133
★Cannon Electric Company.... 64
Chain Belt Company, Baldwin-Duckworth Division.. 95
★Clifford Manufacturing Company Division, Standard-Thomson Corporation....Inside Front Cover
Consolidated Vultee Aircraft Corporation.... 133

D

Douglas Aircraft Company, Inc.... 71
Dow Chemical Company, The, Magnesium Division. 140
Dow Corning Corporation.... 120
E. I. du Pont de Nemours & Company, Inc., Fabrics Division.... 87

E

★Eclipse-Pioneer Division, Bendix Aviation Corporation.... 121
★Electrical Engineering & Manufacturing Corporation 34
A. H. Emery Company, The.... 125
Engineering & Research Corporation.... 126

F

★Fairchild Engine and Airplane Corporation
★Fairchild Aircraft Division.... 53
Felt Products Manufacturing Company.... 100

G

Garrett Corporation, The, AiResearch Manufacturing Company Division.... 4
General Radio Company.... 109
B. F. Goodrich Chemical Company.... 107
B. F. Goodrich Company, The, Aeronautical Division 84
Goodyear Tire & Rubber Company, Aviation Products Division.... 1

H

Hagan Corporation.... 51
Hamilton Standard Division, United Aircraft Corporation.... 127
★Heli-Coil Corporation.... 93

I

Imperial Pencil Tracing Cloth, Keuffel & Esser Company.... 122
Indiana Gear Works.... 114
★Industrial Sound Control, Inc.... 36
International Nickel Company, Inc., The....99, 118

J

★Jack & Heintz Precision Industries, Inc.... 83
Jessall Plastics, Inc.... 42
★Johns-Manville.... 57
★Joy Manufacturing Company.... 75

K

Kendall Company, The, Bauer & Black Division.... 37
Kennametal, Inc.... 59
Keuffel & Esser Company....54, 55
Imperial Pencil Tracing Cloth.... 122
Walter Kidde & Company, Inc.... 77
Kollsman Instrument Corporation.... 45

L

Lamb Electric Company, The.... 58
Linear, Inc.... 129

Advertisers

Lockheed Aircraft Corporation 136
Lord Manufacturing Company 52

M

Marman Products Company Inc. 72
Glenn L. Martin Company, The 61
★Meletron Corporation 67
Minneapolis-Honeywell Regulator Company, Aeronautical Division ..... Back Cover
Minnesota Mining and Manufacturing Company, Adhesives and Coatings Division 47

N

North American Aviation, Inc. 126, 136
Northrop Aircraft, Inc. 52, 90, 91

O

Oakite Products, Inc. 66
Ohio Chemical & Surgical Equipment Company Division, Air Reduction Company, Inc. 66

P

Pacific Scientific Company 81
Pittsburgh Plate Glass Company, Industrial Paint Division 112
Prestole Corporation 48, 49

R

Reid Division, The, The Standard Products Company 65
Resistoflex Corporation 116
Rigidized Metals Corporation 128
★Rohr Aircraft Corporation 73
Rollway Bearing Company, Inc. 79

S

Sandia Corporation 127
★Scintilla Magneto Division, Bendix Aviation Corporation ..... Inside Back Cover, 63
★Sperry Gyroscope Company, Division of The Sperry Corporation 127
Standard Products Company, The, The Reid Division 65
★Standard-Thomson Corporation, Clifford Manufacturing Company Division ..... Inside Front Cover
P. A. Sturtevant Company 112
Surface Combustion Corporation, Aircraft-Automotive Division 68, 69

U

United Aircraft Corporation, Hamilton Standard Division 127
United States Aviation Underwriters Incorporated ... 66
University of Minnesota 133

V

Varflex Corporation 103

W

★Western Gear Works 89
★Wittek Manufacturing Company 122
Wyman-Gordon Company 2

★ *Specifications and further information on the aircraft products of these companies will be found in the*

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TABLE OF CONTENTS

DOWMETAL ALLOYS
- Specifications
- Grades

PROPERTIES
- **PHYSICAL PROPERTIES**
  - Specific Gravity
  - Thermal Expansion
  - Thermal Conductivity
  - Electrical Properties
  - Thermal Stability
- **MECHANICAL PROPERTIES**
  - Tensile Properties
  - Compressive Properties
  - Shear
  - Bearing
  - Modulus of Elasticity
  - Modulus of Rigidity
  - Poisson's Ratio
- **CHEMICAL PROPERTIES**

PRODUCTS MANUFACTURED
- Primary Magnesium
- Alloy Ingots

CASTINGS
- **SAND CASTINGS**
  - Grades
  - Alloys
  - Tolerances
  - Patterns
  - Inserts
  - Heat Treatment
  - Finish
- **PERMANENT MOLD CASTINGS**
  - Alloys
  - Design
  - Dies
  - Heat Treatment

CASTINGS—Cont'd
- **DIE CASTINGS**
  - Alloys
  - Design
  - Dies
  - Sizes and Tolerances
  - Finish

EXTRUSIONS
- Grades
- Alloys
- Dies
- Finish
- Definitions
- Lengths

ROUND RODS, BARS and STANDARD STRUCTURAL SHAPES
- Sizes and Weights
- Tolerances

TUBING
- Sizes and Weights
- Tolerances

FORGINGS
SHEET, PLATE and STRIP
- Grades
- Alloys
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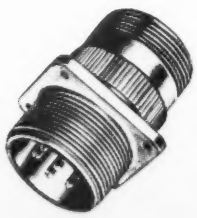

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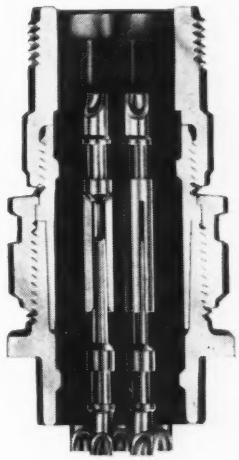

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